INNOVATION REVISITED

HEARING

BEFORE THE

COMMITTEE ON SMALL BUSINESS
HOUSE OF REPRESENTATIVES

NINETY-SEVENTH CONGRESS

SECOND SESSION

WASHINGTON, D.C., MAY 4, 1982

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INNOVATION REVISITED

TUESDAY, MAY 4, 1982

House of Representatives,
Committee on Small Business,
Washington, D.C.

The committee met, pursuant to call, at 9:30 a.m., in room 2359-A, Rayburn House Office Building, Hon. Parren J. Mitchell (chairman of the committee) presiding.

OPENING STATEMENT OF CHAIRMAN MITCHELL

Mr. Mitchell. Good morning. This hearing will now come to order.

This morning's hearing covers innovation. As you will recall, last October this committee unanimously approved H.R. 4326, the Small Business Innovation Development Act.

As reported by the House Small Business Committee in November of 1981, the bill would require 13 Federal agencies with large research and development budgets—over $100 million per year—to establish a program to encourage R. & D. by small business.

Each of the 12 agencies would be required to put a portion of their R. & D. budget into the program. This portion would begin at one-half of 1 percent in the first year and would increase until it reached 3 percent in the fourth and all subsequent years.

Since we reported the bill, six other House committees also considered it. Basically, five of them voted to approve the bill but only after exempting major items from the bill:

Energy and Commerce would exempt Health and Human Services R. & D. estimated at $4 billion;

Armed Services would exempt the Defense Department's R. & D. and atomic energy defense R. & D., estimated at over $20 billion;

Veterans' Affairs would exempt all in-house R. & D., estimated at $10 billion;

Foreign Affairs probably will want to exempt AID R. & D., estimated at $160 million; and

Intelligence would exempt the intelligence community.

The other House committee, Science and Technology, completely restructured the bill. Their two major changes are that the percentages would be reduced to a maximum of 1 percent and, second, the program would be effective each year only to the extent that the authorization committees approved participation for each agency.

These six committees acted after hearing considerable criticism which ranged from statements that "the small business community does not want the program," to "the small business community cannot do the work."

Today's hearings are for one purpose—to allow the small business community the opportunity to rebut these criticisms. We have a terrific amount of talent assembled here to do this.

I must indicate my own anger, that is the right word I want to use, my own anger at some of the gross distortions that are being put out to the public by the opponents of this bill, all sorts of gross distortions, and I hope we will be able to speak to each one of those, certainly in committee, and when we are on the floor.

Our other members are here, Mr. Neal Smith. Do you care to make an opening statement?

Mr. **Neal Smith**. No, Mr. Chairman.

Mr. **Mitchell**. Mr. Bedell.

Mr. **Bedell**. Yes, I do, Mr. Chairman.

OPENING STATEMENT OF HON. BERKLEY BEDELL, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF IOWA

Mr. **Bedell**. I welcome the opportunity that this hearing presents to us as we try to clear up the confusion that has surrounded this very important piece of legislation that is so clearly in the national interest. I commend your initiative and your leadership on behalf of the Small Business Innovation Research Act.

I do not believe it is necessary for us to put in the record one more time just how innovative, productive and job creating small businesses are. Those attributes have been documented over and over.

Rather, the time has come for the Congress to respond with action. In a short time this body will be confronted with a bill that will put the value of all that documentation to a test. At that time we must send a clear message to those who say the status quo is good enough. It is not. We must choose to move forward and develop new industry in our country.

To do that, we must encourage new ideas from as many different sources as possible. We cannot afford to be myopic and must not be afraid to look beyond our traditional institutions for ideas that will lead us into the future. We presently have a huge problem of encouraging technology transfer in our economy. I see this bill as a vehicle to foster technology transfer.

Actually, I should say that our technology transfer system, works better for our international competitors than it does for us. You see, the U.S. Government spends money that trains and supports engineers and scientists to perform all sorts of research that ends up adding to the body of human knowledge. Our Nation's research, and the Government funds half of it, is published in the world's most prestigious scientific journals and wins the bulk of Nobel Prizes.

Meanwhile, the Japanese and rest of the world read these scientific journals and search our patent files and sell products of research back to us. One example of this is in the field of robotics. Developed in the United States, the science of robotics has been perfected and marketed by the Japanese. Japan is now the leading source of industrial robots in the world. The United States, because of its inability to convert the fruits of its research into a useful product, has lost this valuable market to a foreign competitor.

Mr. Chairman, I will not take up too much more time. I know a few people have stirred up a lot of opposition to this bill. I hope our witnesses will address their remarks to the issues raised during the debate on this legislation and help us create a record that will guide the Small Business Innovation Research Act through the House.

I thank you very much.

Mr. **Neal Smith**. Mr. Chairman.

Mr. **Mitchell**. Mr. Smith.

Mr. **Neal Smith**. I will just say something. I, of course, am for the bill. I have been, as one of the original promotors of the idea. I know that the main arguments used against the bill are still based upon the idea that we should not have set-aside, that everything should be competitive. But I just want to repeat that we have found over the years that, as a matter of fact, the existing system is not competitive. One of the areas that opponents like to talk about is the National Institutes of Health.

And even at the National Institutes of Health, where we are dealing with health, the people tend to say we do not want to be bothered if you are not big. We just do not want to be bothered with working on small contracts.

And so it is very important, and I hope we would get this bill going as fast as we can.

Mr. **Mitchell**. Thank you very much.

I would ask unanimous consent that the opening statements of Congressman Addabbo, and Congressman LaFalce who will join us later, and Congressman McDade be submitted for the record in their entirety. All three of these members of the committee strongly support this bill.

OPENING STATEMENT OF HON. JOSEPH P. ADDABBO, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEW YORK

Mr. Chairman, I am sorry that I cannot be here personally, but I must chair another hearing on the Defense Appropriations Subcommittee at the same time. I appreciate your accepting these written remarks for the hearing record. I commend you and the other members for their active support of H.R. 4326, the Small Business Innovation Development Act, and extend to you my continuing support for this important legislation.

I would like to comment briefly on some of the criticisms of H.R. 4326 as it pertains to research and development at the Department of Defense. Over the years, I have been a strong advocate of encouraging the Department of Defense to do more business with small firms. Five years ago, I introduced what later became Public Law 95-507, which in part requires DOD and other agencies to establish small business goals and encourages greater subcontracting with small businesses. Congress reached the point that it could not rely on empty promises to encourage greater use of small businesses. Today, we are at another threshold, where we must act to offset our Nation's decline in innovation and productivity.

H.R. 4326 is but one step toward resolving this crisis, Even so, resistance is formidable from the prime beneficiaries under the current procurement scheme. The facts, however, support the need for this legislation, and the criticisms are either unfounded or not deserving of a conclusion that there should be no such small business initiative.

Proponents of exempting the Department of Defense from the proposed legislation claim that defense research will suffer if a miniscule percentage of DOD's R. & D. budget were spent through an SBIR program. The fact of the matter is that DOD would retain full discretion to unilaterally determine suitable subject areas for the program. Also, DOD would retain the ability to determine how to fund the program, and the dollar amount of individual grants. In addition, prior experience with the defense science and technology (DESAT) program shows that such a program need not be complicated and that open competition will be fierce for SBIR grants.

There also is criticism that there are not a sufficient number of qualified small businesses to do defense research. In fact, the Small Business Administration estimates that 15,000 to 20,000 small firms do research and development as their principal work.

In sum, this legislation would not be necessary if small firms were able to assume their proper place as Government contractors. Instead, they receive less than 7 percent of the Federal R. & D. pie, and even that has been shrinking every year. Only our affirmative action will be able to reverse this trend to a point where the United States will be able to resume its place as the preeminent innovator in the world.

Thank you.

OPENING STATEMENT OF HON. JOSEPH M. McDADE, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF PENNSYLVANIA

Mr. Chairman, let me commend you for calling this hearing on H.R. 4326, the Small Business Innovation Development Act. Since we've reported this bill out of committee, six other committees have held hearings and recommended changes to the bill. It is important that we review the actions these committees have taken.

I continue to strongly support the innovation bill. Small business is a source of much technical innovation. Unfortunately, the Government's record in awarding R. & D. funds to the innovative small business firms continues to be unacceptable. In spite of our repeated efforts, it is clear that agencies continue to be reluctant to deal with small businesses.

As you have noted, the other committees have recommended many amendments. Some of these may well prove to be constructive changes, but I believe that others are merely attempts to gut the bill. Today's hearings will give us a chance to hear experts from the public, private, and academic sectors. I look forward to their comments on the various arguments which have been raised concerning the bill.

Mr. MITCHELL. Our first witness this morning is Hon. Frank Swain, Chief Counsel for Advocacy.

Thank you very much for being with us this morning.

PANEL CONSISTING OF FRANK S. SWAIN, AND MILTON D. STEWART

TESTIMONY OF FRANK S. SWAIN, CHIEF COUNSEL FOR ADVOCACY, SMALL BUSINESS ADMINISTRATION

Mr. SWAIN. Thank you very much, Mr. Chairman.

You have a very distinguished witness list indeed. I am pleased to say that most of the witnesses are generally small business people and know far more directly the need for this legislation, so I will be brief and hopefully to the point.

I have a prepared statement and request that you admit it for the record.

Mr. MITCHELL. Without objection, your statement in its entirety will be submitted for the record.

[Mr. Swain's prepared statement follows:]

PREPARED STATEMENT OF FRANK S. SWAIN, CHIEF COUNSEL FOR ADVOCACY, SMALL BUSINESS ADMINISTRATION

Mr. Chairman and members of this committee, thank you for the opportunity to testify today in support of the small business innovation legislation pending before Congress. As you know, the President has endorsed S. 881, the Small Business Administration Research Act of 1981. Last week, the Small Business Administration Advisory Council also endorsed S. 881. The ten member Coalition of Small and Independent Business Associations (COSIBA) unanimously supports passage of this legislation.

The reasons for the widespread support are twofold. First, the Small Business Innovation Research program, if implemented, offers a partial solution to our country's problem of declining productivity. Second, the SBIR setaside will help to gain for small business a fairer share of Federal R. & D. funds.

Regarding the first point, there is considerable evidence indicating that our preeminent position as a world leader in technological innovation has changed to that of a follower. From 1970 to 1980, the number of patents filed with the U.S. Patent Office dropped 13 percent. Twenty-five percent of the U.S. patents issued in 1970 went to residents of foreign countries—40 percent in 1980. Our country's annual increase in productivity has declined tenfold in the past ten years, and has been surpassed by several European countries and Japan. In 1980 Japanese firms and individuals received close to 11 percent of all U.S. patents issued. I believe this decline is a critical national problem.

Regarding the second effect of this legislation, the low rate of participation by small business in Federal R. & D. funds is fairly well documented. Of the Federal R. & D. funds awarded on contracts and grants in fiscal year 1981, small business received: 1 percent of the grant funds, 6 percent of the contract funds in contract actions $10,000 and over; and 5 percent of the total grant and contract funds awarded.

The other 95 percent go to large firms, universities and other nonprofit entities. Many of these firms are very large. Just 70 firms do 80 percent of this research. Roughly 60 percent of these funds are awarded non-competitively. Thus, for the most part, small business could not increase its share of these funds regardless of how hard it collectively worked or competed or proved itself. Adjusting upward the small business share of Federal R. & D. funds is another critical purpose of the legislation.

I wish to note that S. 881 is not, as some would paint it, small business welfare bill. Rather, it is a serious congressional attempt to respond to the national problem of declining productivity by harnessing the creative, productive and innovative capabilities of small R. & D. firms to national needs.

Some doubt that small business is an above average innovative and dynamic economic force. Doubters ask: Can small business be even a partial solution to the decline in our national productivity? Others ask: Can we afford the opportunity costs in reallocating R. & D. funds from universities and large business to small business, even at the low percentage level proposed in S. 881?

The answer is yes, on both counts. Small business is more innovative per employee than large business, to an extent that justifies the reallocation of funds proposed in S. 881, and we now have independent study results to support that claim.

A forthcoming study funded by our Office has demonstrated that small business is 2.5 times more innovative per employee than large business. The contractor is still finalizing that report, but I am previewing today to this Committee and the public the significant findings of that study.

Up to now, evidence regarding the innovative capabilities of small business has been largely intuitive. Gellman Research Associates, in an independently conducted study funded by our Office sampled over 600 innovations of large and small firms. Applying statistical tests of significance, they found that: small firms are 2½ times as innovative per employee as large firms; large firm innovations are over 2½ times more likely to be publicly funded than small firm innovations; and small firms bring innovations from performance criteria to production in 73 percent of the time of large firms.

Thus, small businesses are considerably more innovative per employee than large business and commercialize their innovations faster despite the fact that small business innovations are less likely to be supported by public funds.

It is a striking finding that large business innovations are 2½ time more likely to be supported by public funds than small business. Even with this decided funding advantage, large firms innovate 60 percent less than small R. & D. firms per employee. This unexpected double finding dramatically underscores the innovative potential and capability of small firms.

The significance of these findings cannot be overstated. In light of these findings, reallocation of Federal R. & D. funds to small business is sound, cost-effective public policy, and a matter of national urgency.

The Gellman study has proven what we have known intuitively for years: That small business creativity has been enhancing the quality of life for all of us. My office has compiled a list of 55 significant innovations contributed by American small business in the 20th century. That impressive list is attached.

There are some yet who remain unconvinced. Opponents of S. 881 have presented a variety of arguments that do not stand the test of scrutiny. They have suggested that the unanimous Senate vote is an indication the Senators did not closely examine the bill. Yet the facts are that S. 881 was the subject of five days of legislative hearings, had 86 co-sponsors, was debated on the Senate floor for two days and amended twice. The fact is that the SBIR is patterned after the National Science Foundation (NSF) SBIR program, a very competitive program. The NSF received eight times the number of applications they had money to fund; only half of the Phase I applicants were chosen to proceed to Phase II funding. The Department of Defense SBIR program received ten times the number of proposals it could fund. The SBIR program is probably the most competitive program in all of Federal R. & D.

The legislation has been called a raid on basic research funds. It is not. S. 881 places a cap of 1 percent of the basic research funds of an agency which can be allocated to the SBIR. Not all of the 1 percent will come from monies currently directed to universities, and in fact some may return to universities in the form of subcontract arrangements. The net effect to the universities of this bill could in fact approach zero.

Finally, it has been claimed that small business receives currently all the R. & D. funds its scientists and engineers are capable of handling. That is not true. Using employment of scientists and engineers as a measure of capability, we calculate that small business is funded at one-third of its current capability.

In examining all of the arguments against S. 881 of which we are aware, my office has found none that stand the test of scrutiny.

Yet, these arguments have found favor with various House committees, and the result is a series of amendments reported on the House bill, which if enacted, would seriously undermine the basic purposes of the legislation.

There was a pattern of amendments by which other Committees recommended exempting certain R. & D. programs from coverage of the bill. Specifically, they collectively recommended that the R. & D. programs of DOD, CIA, AID, NIH and all GOCO's be exempted.

Regarding the exemptions, it should be noted that S. 881 already would limit coverage of the program to agencies with extramural R. &. D. budgets over $100 million. That leaves R. &. D. programs at only six agencies covered: DOD, DOE, NSF, NASA, USDA and HHS. NSF already has an SBIR program. The House amendments would remove two agencies (DOD and HHS) leaving only four programs covered. Removal of the GOCO's would be tantamount to exempting DOE as well. I believe that all of the programs covered by S. 881 could benefit from an SBIR program. For the above reasons I am opposed to all of these recommended exemptions.

In conclusion, I would like to note that this legislation offers the Congress an opportunity of historic dimensions to stimulate our rate of productivity and to assist the small business sector at the same time. Time is of the essence on both counts.

The sooner a bill is passed and signed into law, the sooner both benefits can begin to accrue.

Some important innovations by U.S. small firms in the 20th century are:

Acoustic suspension speakers; aerosol can; air conditioning; airplane; artificial skin; assembly line; automatic fabric cutting; automatic transfer equipment; bakelite; and biosynthetic insulin.

CAT scanner; catalytic petroleum cracking; continuous casting; cotton picker; double-knit fabric; dry chemical fire extinguisher; electrical wire nuts; electronic calculator; fiber optic examination equipment; fluid flow meter; foam fire extinguisher; geodesic dome; and gyro compass.

Heart valve; heat sensor; helicopter; heterodyne radio; high capacity computer; hydraulic brake; learning machine; link trainer; optical scanner; oral contraceptives; outboard engine; and overnight national delivery.

Personal computer; photo typesetting; piezo electrical devices; polaroid camera; precast concrete; prefabricated housing; pressure sensitive cellophane; and rotary oil drilling bit.

Safety razor; six-axis robot arm; soft contact lens; sonar fish monitoring; spectographic grid; stereoscopic map scanner; strain gauge; strobe lights; vacuum tube; variable output transformer; xerography; and zipper.

Note: An innovation is the first sale using a discovery. A small firm is defined as having less than 500 employees.

Source: Compiled March 1, 1982, by the Office of Economic Research, Office of Advocacy, U.S. Small Business Administration, Washington, D.C.

Mr. SWAIN. I think the interest of the small business community in this legislation has been well documented and by the time the legislation has worked its way through the House and Senate, that enthusiasm has greatly increased.

I can report that the National Advisory Committee to the Small Business Administration in its first meeting last Friday unanimously endorsed the need for innovation legislation to be passed immediately by the Congress and approved by the President.

Reasons for such widespread small business support are twofold. First, the Small Business Innovation Research program, if implemented, offers a partial solution to our country's problem of declining productivity. Second, the SBIR set-aside will help to gain for small business a fairer share of Federal R. & D. funds.

In an effort to try to put some facts where a lot of rhetoric has been in the past, the Office of Advocacy contracted with a research firm to bring more data to bear on the issue. I am happy to be able to preview the data with you this morning, and report that the final study will be released in approximately 10 days.

Gellman Research Associates, Inc., of Philadelphia, in an attempt to track the small business innovation record as well as the record of innovation in public funds, surveyed 600 business innovations reported from 1970 to 1980.

The significance of their findings are twofold. First, they found that small firms tend to be 2½ times more innovative per employee than large firms. Second, and I think of even greater significance, they found that large firm innovations were 2½ times more likely to have received Government funding than small firms.

Clearly there is a disadvantage inherent in the system we have now. That is why it is absolutely appropriate and necessary for the Congress to remedy this disadvantage through the small business innovation research program. It is a striking finding that large firms are 2½ times more to be supported by public funds. Even with this advantage, large firms innovate 60 percent less than small firms per employee.

This unexpected finding dramatically underscores the potential and capability of small firms. The significance of the findings cannot be overstated. In light of these findings reallocation of Federal R. & D. funds to small business is sound, cost-effective public policy and a matter of national urgency.

I would like to remind the public for the record that this is a program that has been endorsed by the administration. The President specifically endorsed it in his report to the Congress on the state of small business. In the process of preparing this testimony, I contacted officials of the administration to make sure this endorsement still held.

They assured me it did still hold in the strongest way, that they were absolutely behind legislation regarding S. 881 and similar legislation that could solve some of these innovation problems we have had.

As you mentioned in your opening statement there have been some activities in the House in the other committees which I think detract considerably from the legislation. We mention those in our testimony. In particular I think that it is absolutely foolhardy for the Congress to go through the effort of debating and passing legislation from which major agencies such as Department of Defense, Department of Energy and Government corporations, and the National Institutes of Health, have been exempted.

Again in preparing this testimony I specifically contacted the OMB to make sure that my testimony in opposition to those exemptions was a statement of administration policy. I am happy to report that the administration is, in fact, opposed to these exemptions. It has announced its full endorsement for S. 881-type legislation, and S. 881 carries no such exemptions.

Therefore, I am here this morning not only to reiterate the support of the small business community because you have ample representation from the small business community this morning, but also to let you know that the administration stands fully behind S. 881-type legislation. I realize there are some differences between H.R. 4326 and S. 881. I am confident they can be worked out in the legislative process.

Certainly there is no reason to delay the legislation any longer. As Congressman Bedell said, the role small business plays has been well documented and we hope the Congress can act quickly on the legislation.

Mr. MITCHELL. Thank you very much. I assure you we do intend to act quickly.

If my colleagues would agree, I think we would like to hold our questions. Let's hear from one more witness.

Mr. Stewart will come up. Then we can put questions to both of the gentlemen. Mr. Milton Stewart.

TESTIMONY OF MILTON D. STEWART, EDITOR, INC. MAGAZINE, AND FORMERLY CHIEF COUNSEL FOR ADVOCACY, SBA

Mr. STEWART. Mr. Chairman, thank you.

If I may, I would like to offer for the record a set of charts about this subject and a prepared statement. The president of BioLabs would like to offer his prepared statement for the record. Dr. Goodheart is a professor of medicine and immunology at Rush Medical College, and regrettably cannot be with us today. He has asked me to ask the committee to accept his statement.

Mr. Mitchell. Both statements will be submitted in their entirety for the record.

[The prepared statements of Mr. Stewart with accompanying charts, and of Dr. Goodheart, follow:]

PREPARED STATEMENT OF MILTON D. STEWART, EDITOR, INC. MAGAZINE, AND FORMERLY CHIEF COUNSEL FOR ADVOCACY, SBA [1]

This is my first appearance before this Committee since my return to private life more than a year ago. It is therefore the first opportunity I have had to thank you on two counts. First, for your diligence and responsibility in serving the Republic. Although I have respected it for many years, my three years in Washington taught me again how important it is. And I want to thank you for your unfailing kindness and courtesy and support during that period.

This is also an appropriate time and place to be sure your record on this measure reflects accurately the great contribution made to the success of the Small Business Innovation Research program of the National Science Foundation of Roland Tibbetts, who has managed it with great effectiveness and distinction.

Mr. Tibbetts—and I know I speak for hundreds of small business people who came to know him—deserves great credit for earning and holding their confidence. Many of them had given up on the Federal government; they had stopped believing that it could do business with them simply, directly, sensibly and fairly. Mr. Tibbetts won their respect the hard way—by being tough but fair, and by his selfless concern that the program be given a fair chance to succeed or fail, measured by what it could do for our country. The way of the pioneer is no easier in government than anywhere else. There were many times I am sure that this businessman turned career public service science administrator needed the same qualities that won him the Distinguished Flying Cross during World War II.

There are a number of competent scientists, scholars, and entrepreneurs here to testify today. I would like to leave them as much time as possible. In addition, the record you have made over the years on this subject is already massive. For those reasons I would like to limit my own remarks sharply.

The attached charts will, I hope, help the members of this Committee and their colleagues in the House to focus on the simple fact that makes this legislation's prompt enactment urgent: the country needs it.

When we began the discussions which led to the first competitive Small Business Innovation Research Program at the National Science Foundation, our concern was with fairness to small business. That was in 1975–76. We were responding to many expressions of rage and frustration by highly qualified technology entrepreneurs in small business. They had the feeling that despite outstanding technical capability, research experience, and educational training—they had not been treated fairly in the principal agencies dispensing Federal research and development funds.

That has not been our principal concern for the past three or four years. More and more we have come to see this program in terms of national needs. This has been particularly true as we have watched our great industries lose position in domestic markets which they had taken for granted for generations. As industry after industry has had to lay people off, the connection among technology, small business, and the achievement of small scale enterprise research and development has become clearer and clearer.

I have read carefully every critical statement by an opponent of this legislation. I have read the arguments made by the spokesmen for the academic overhead community, the career procurement officials, and the tiny group in the electronics industry which has expressed opposition. There are answers, and good ones to each of the questions or fears or doubts raised by those who oppose this program. The best possible answer would come from not less than five years of experience with it throughout the government. It is my own view that that would turn these groups who have formed a coalition against needed change into advocates.

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[1] Editor, Inc. Magazine, Boston; counsel, Chapman, Duff and Paul, Washington; president, Stewart Small Business Associates, Phoenix, Ariz.; formerly Chief Counsel for Advocacy, U.S. Small Business Administration.

They would conclude, as I have, that this promising approach delivers in three ways that are only too rare in the Federal Government:

1. It is based on open competition and merit. That is not the case generally for R. and D. contracting; 70 percent of the funds are spent without the spur and the safeguard of competition. The sole limitation on the competitive field is the exclusion of large firms, non-profit institutions and government laboratories. This affects no individuals in those institutions; all are or can make themselves eligible. The "institutional" limitation makes functional sense: it is small-scale research that is sought; it is government-needed but market-applicable products and processes that are sought.
2. It is a program which stimulates entrepreneurship in the private sector as against bureaucracy. Almost every other Federal program has the Federal agency bureaucracies giving preference directly or indirectly to their private sector mirror images: large business and large nonprofit institutions.
3. It is that rarest of Federal programs—one that will deliver measurable, undeniable and favorable returns to taxpayers for the investment of their funds. Gains in jobs and taxes paid promise to follow the proven cost-benefit pattern of the much older SBIC program.

The charts submitted with this testimony—and the other witnesses you will hear today—should be answer enough to the arguments of those who resist this urgently needed advance. We are in a new science-technology-business ballgame. Whether we stay in the major leagues will depend substantially on whether we can change fast enough to adjust to its new requirements.

I will be pleased to elaborate on these statements of disagreement with those in opposition:

1. This program will strengthen the case for basic science support in the long run. It will help to forge a stronger link between basic science and applied industrial technology in our own country. Foreign competitors are now using our basic science—totally available to them and more quickly all the time—to advance technologies which they then use to penetrate our markets, faster than our present machinery permits.
2. Private venture capital cannot alone do what we need. The selection of nationally relevant and promising technologies by NSF has helped speed venture capital financing to firms which otherwise could not get it.
3. There need be no excessive diversion of discretionary or basic science funds beyond the sharply limited 1% or 3% provided. Where to find the money is left to agency managers and Congressional oversight.
4. The idea that the "real problem" is excessive government regulation fails to distinguish a necessary and a sufficient cause. We need less regulation—my own experience in that fight is not small—but that alone will not do what we need.
5. This program chooses the best performer in a vigorous and fair competition. Not to see that is not to understand why Mohammed Ali is not a fair match for a 125 pound lightweight. Size and "for profit" focus on the market are not irrelevant social characteristics here. They are sensible, goal-relevant standards of eligibility.
6. Agencies which claim there are not enough small firms to provide an adequate field of competition are simply showing how unattractive they have made their programs to small firms. If the specially-designed competitions are there on a firm and predictable basis, there will be—and already are—plenty of competent and qualified small firms. If there are a small number of reasonable exemptions needed, they can be provided by Congress.
7. Universities will benefit from this program. They will do better with it if they allow faculty members reasonable freedom to engage in limited independent off-campus work. The same is true of Federal agencies which try to chain personnel to their jobs with in-house research opportunities alone.

SMALL BUSINESS INNOVATION
DEVELOPMENT PROGRAM
(H. R. 4326)

HOUSE COMMITTEE ON SMALL BUSINESS

CHARTS TO ACCOMPANY TESTIMONY OF
MILTON D. STEWART

GRAPHICS PREPARED USING GRAPHWRITER
A PRODUCT OF GRAPHIC COMMUNICATIONS, INC.,
A WALTHAM, MASSACHUSETTS SMALL BUSINESS

GRAPHICS REPRODUCED BY COPY COP,
A BOSTON, MASSACHUSETTS SMALL BUSINESS

IN THE 1980s THE NATION WILL
HAVE FIVE MAJOR NEEDS

1. MORE JOBS
2. MORE COMPETITIVENESS WITH FOREIGN INDUSTRY
3. A BETTER BALANCE IN THE NATIONAL SCIENCE BASE
4. SPREADING BENEFITS OF HIGH TECHNOLOGY GROWTH THROUGHOUT THE NATION
5. CONTINUED EFFORTS TO REDUCE GOVERNMENT COSTS

SMALL BUSINESS CAN HELP--
IF IT IS ENCOURAGED TO DO SO

NATIONAL SCIENCE FOUNDATION INNOVATION RESEARCH BASIC DATA

THREE PHASE APPROACH

PHASE I	FEASIBILITY EFFORT - $30,000	6 MONTHS
PHASE II	PRINCIPAL RESEARCH PROJECT - $200,000	1-2 YEARS
PHASE III	DEVELOPMENT - PRIVATE FUNDING	

EARLY RESULTS OF NSF SBIR

NOT CONCLUSIVE BUT EARLY RESULTS ARE MOST PROMISING: WINNING FIRMS HAVE ATTRACTED FAR MORE PRIVATE FOLLOW-ON FUNDING THAN AMOUNTS OF FEDERAL GRANTS

NSF SBIR: DRAMATIC JOB GROWTH AND FOLLOW-ON FUNDING

($ MILLION) SOLICITATION	NSF RESEARCH		PRIVATE FOLLOW-ON FUNDING	SBIR TOTAL
	I	II	III	
1977	1.0	4.3	41.4	46.7
1979	1.2	2.4	5.7	9.3
1980	1.5	.7	--	2.2
1981	2.5	--	--	2.5
	$6.2	$7.4	$47.1	$60.7

*DUE DIRECTLY OR IN PART TO SBIR AWARDS

Average Employment per Firm: 1977 - 18; 1982 - 40

Increase in Employment: From 338 in April 1977 to 762 now

Percentage Growth in Jobs: 125%

NSF SBIR PROGRAM PROPOSALS RISE STEADILY

	PROPOSALS	PHASE I AWARDS	PHASE II AWARDS	PHASE III*
1977	329	42	21	11
1979	408	54	13	4
1980	503	62	5*	--
1981	696	85	--	--
	1963	243	39	15*

*TO DATE PRIVATE SECTOR FOLLOW-ON FUNDING

NSF SBIR SOLICITATION REACHES SMALL FIRMS OF VARYING SIZES

	PHASE I				PHASE II	
SOLICITATION	AWARDS	AVG. NO EMP	10 OR LESS EMPLOYEES NO.	%	AWARDS	AVERAGE NO. OF EMPLOYEES
1977	42	20	19	45	21	21
1979	54	36	30	56	13	20
1980	62	43	27	44	5*	28
1981	85	47	37	44	--	--
TOTAL	243	40	113	47	39	22

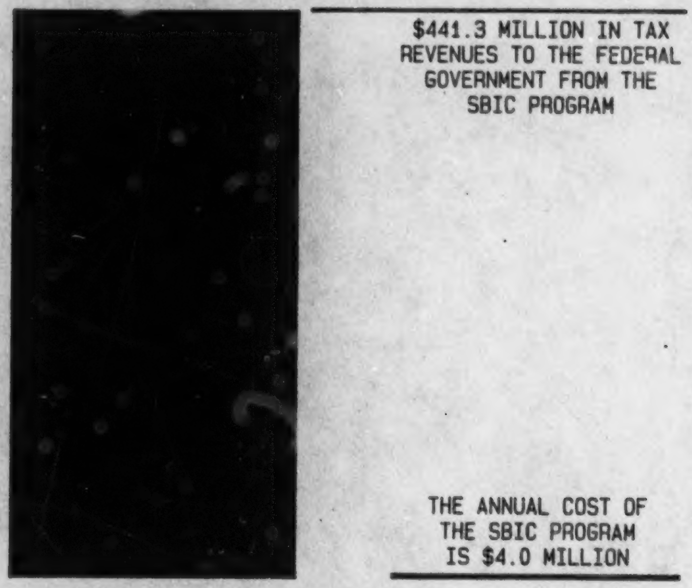
RANGE OF EMPLOYEES IN GRANTEE FIRMS 1-498
* TO DATE, MORE AWARDS IN PROCESS

MARCH 1982

BOTH THE SBIC PROGRAM AND THE SBIR PROGRAM:

1. FOCUS ON THE JUGULAR POINT OF SMALL BUSINESS GROWTH;
2. MAKE MAXIMUM USE OF ENTREPRENEURS AND THE PRIVATE SECTOR; AND
3. LIMIT GOVERNMENT'S ROLE PROPERLY.

THE SBIC PROGRAM IS ONE OF THE BEST INVESTMENTS OF THE AMERICAN PEOPLE

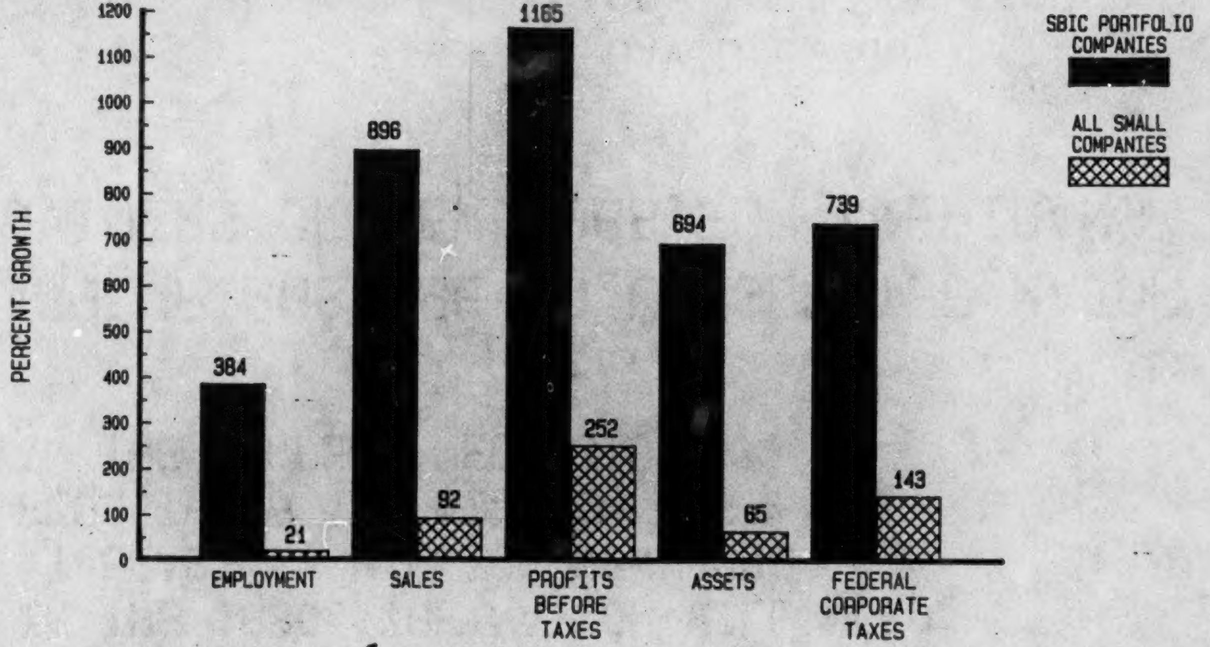


SOURCE: *Deloitte Haskins & Sells 1981 Study,*
"Cost-Benefit Study of the SBIC Program"

SBIC PROGRAM APPARENTLY HAS OVERWHELMING COST-BENEFIT RESULTS FOR TAX PAYERS

SOURCE: DELOITTE, HASKINS & SELLS, 1981

SBIC PORTFOLIO COMPANIES OUTPERFORMED ALL SMALL COMPANIES IN FIVE MAJOR PERFORMANCE CATEGORIES IN THE 1970-1979 TIME PERIOD



SOURCE:
Federal Trade Commission, Quarterly Report of Manufacturing Corporations and U.S. Bureau of the Census, County Business Patterns and Arthur D. Little, Inc. Estimates

MORE JOBS

IN THE 1980s THE NATION WILL NEED
AT LEAST 15 MILLION NEW JOBS
PLUS THE 5 1/2 MILLION LOST
IN THE 'CURRENT RECESSION

"LARGE FIRMS ARE NO LONGER THE MAJOR PROVIDERS OF NEW JOBS FOR AMERICANS"

--DAVID BIRCH
MASS. INST. OF TECH.

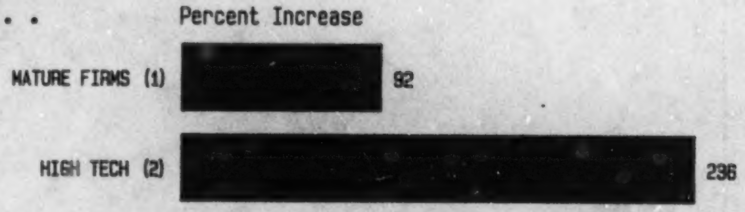
SOURCE: BIRCH, "THE PUBLIC INTEREST", FALL 1981

AFTER MORE THAN 25 YEARS, SBIC
PROGRAM POINTS TO PROBABLY
FAVORABLE LONG-RANGE RESULTS
FOR EXPANDED SBIR PROGRAM

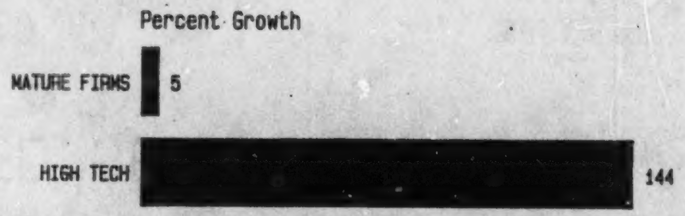
SOURCE: DATA FROM A.D. LITTLE and
DELOITTE, HASKINS & SELLS

RECENT DATA CONFIRMS THE RELATIVE DECLINE IN EMPLOYMENT IN OUR LARGEST COMPANIES AS COMPARED WITH NEW HIGH TECHNOLOGY VENTURES

HIGH TECH COMPANY SALES NOT ONLY GREW 2.5 TIMES FASTER BUT . . .



. . . PROVIDED NEARLY ALL THE GROWTH IN JOBS

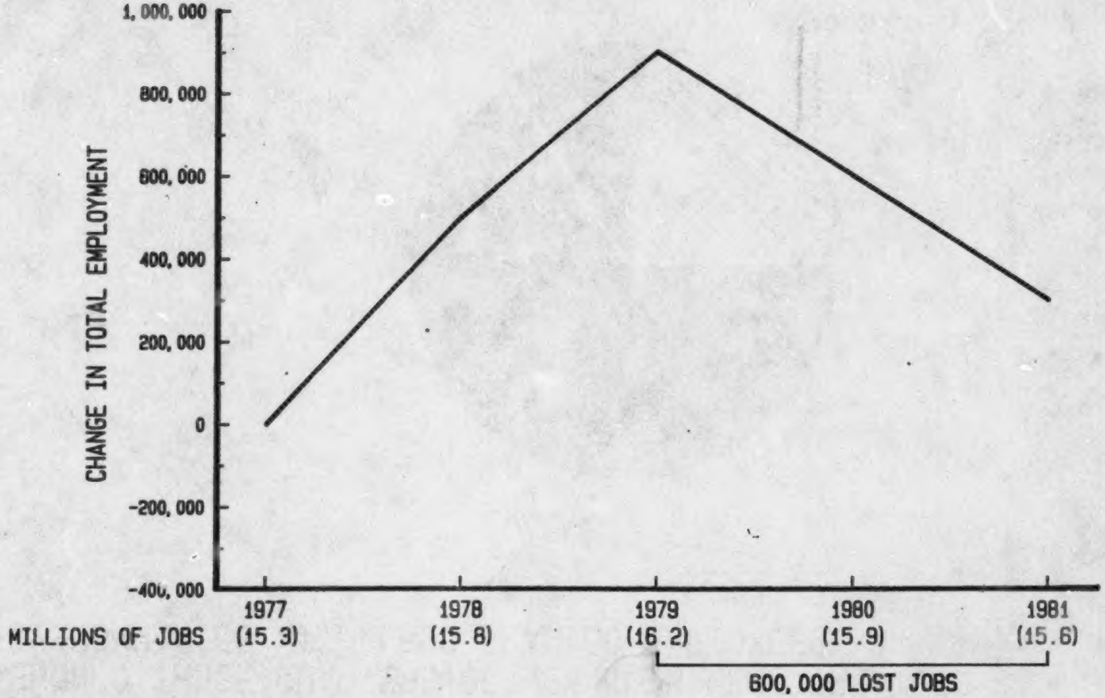


(1) BETHLEHEM STEEL, DuPONT, INTERNATIONAL PAPER, U.S. STEEL, MOBILE, EXXON PROCTOR & GAMBLE, GENERAL ELECTRIC, GENERAL FOODS, AND MARATHON OIL

(2) DATA GENERAL, NATIONAL SEMICONDUCTOR, COMPUGRAPHIC, DIGITAL EQUIPMENT, MARION LABS, WANG AND COMPUTIVISION

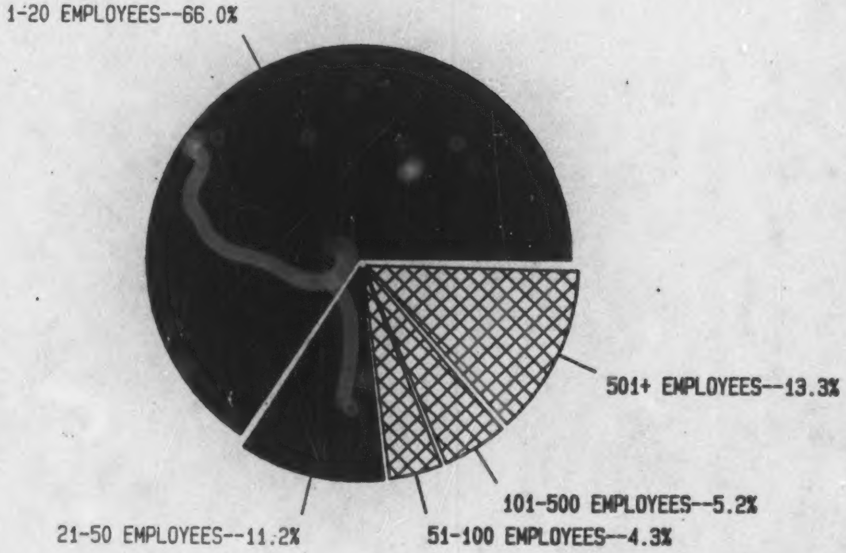
SOURCE: MIT Development Foundation Study "The Role of New Tech Enterprise in the U.S. Economy" 1975

FORTUNE 500 COMPANIES HAVE DROPPED 600,000 JOBS IN TWO YEARS - 1979-1981



SOURCE: Fortune 500: Annual Reports

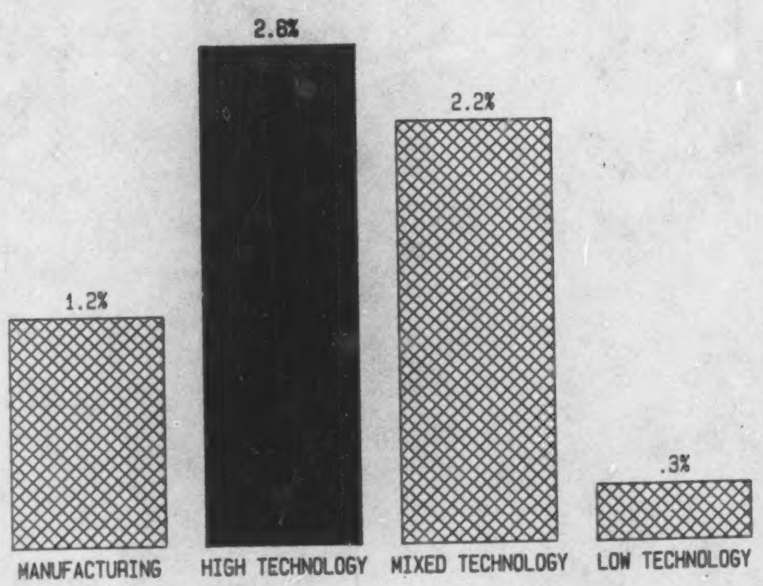
A 1969 TO 1976 SAMPLE OF 5.6 MILLION BUSINESSES SHOWED THREE QUARTERS OF NEW JOBS WERE CREATED BY COMPANIES WITH LESS THAN 50 EMPLOYEES



SOURCE: Birch, "The Public Interest"

HIGH TECHNOLOGY COMPANIES PROVIDE MORE JOBS

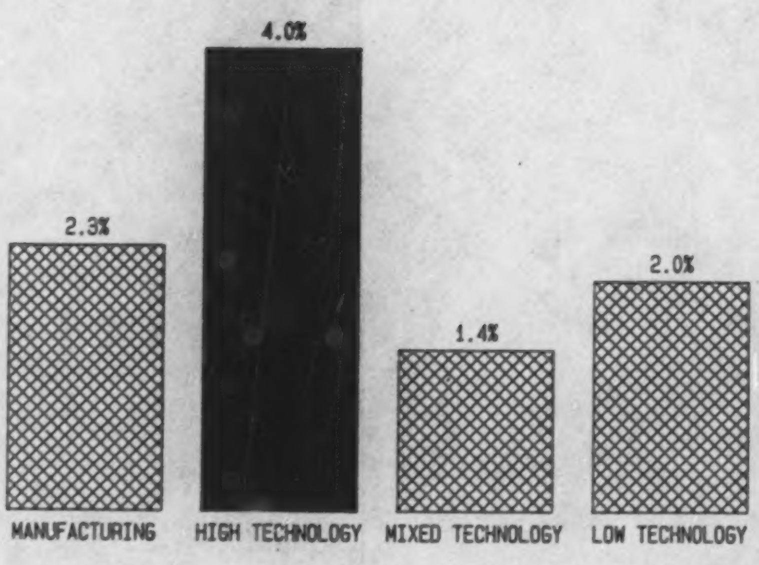
FROM 1950 TO 1974 HIGH TECHNOLOGY COMPANIES
HAD THE HIGHEST EMPLOYMENT GROWTH RATE



SOURCE: Data Resources, Inc.

HIGH TECHNOLOGY EMPLOYEES PRODUCE MORE

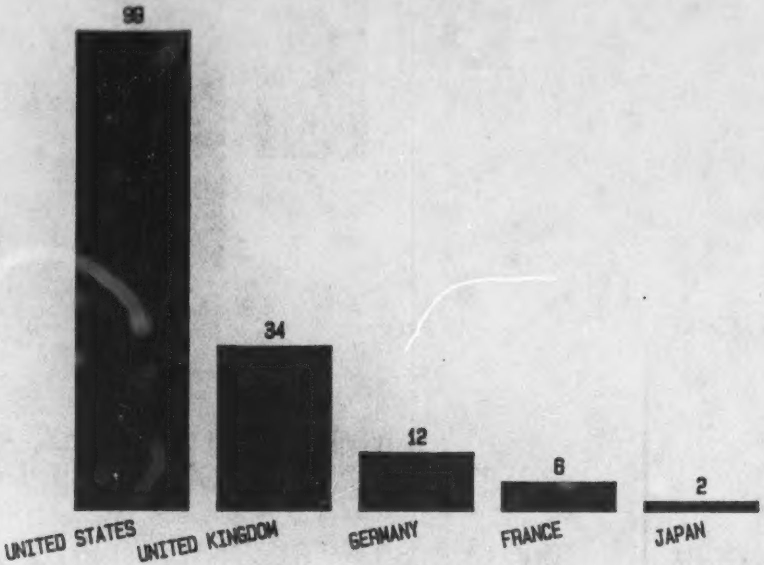
FROM 1950 TO 1974 IT HAD THE HIGHEST COMPOUND
GROWTH RATE OF OUTPUT PER EMPLOYEE



SOURCE: Data Resources, Inc

MORE COMPETITIVENESS WITH FOREIGN INDUSTRY

U.S. BASIC SCIENCE PREEMINENCE: NOBEL AWARDS,
1950-80 (By individual winner)

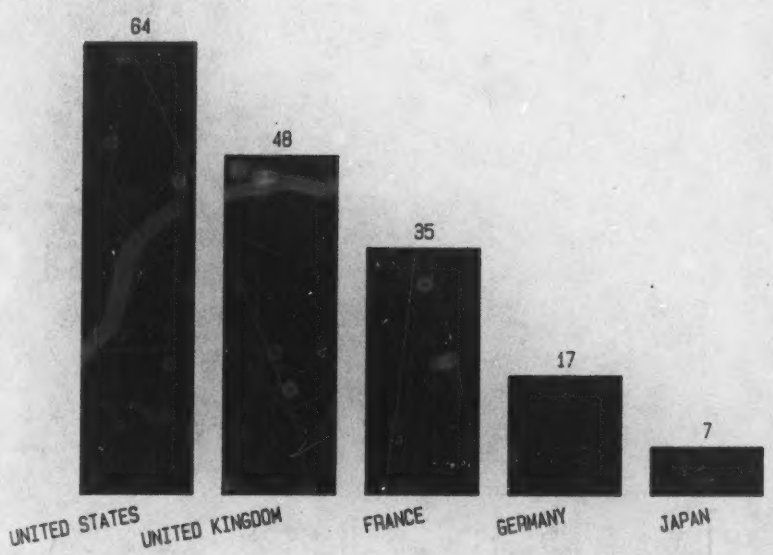


SOURCE: 1981 World Almanac

YET WE NO LONGER LEAD IN AUTOS, STEEL, TV SETS, COPIERS AND ... NEXT?

GOVERNMENT R&D: U.S. DEFENSE/SPACE SHIELD vs. OTHER NATIONAL GOALS

(1974-76 NSF est.)



SOURCE: National Science Foundation Report

BETTER BALANCE IN A STRONGER NATIONAL SCIENCE BASE

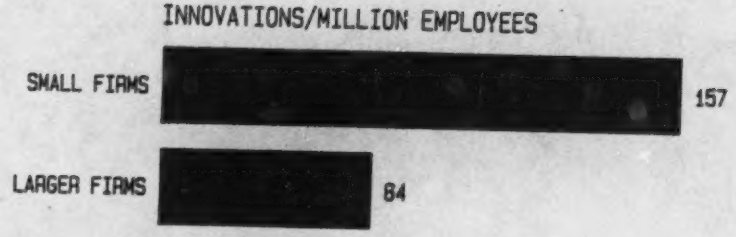
* LARGE COMPANIES
* GOVERNMENT LABORATORIES
* UNIVERSITIES & NON PROFIT RESEARCH LABS
* SMALL BUSINESS

OR

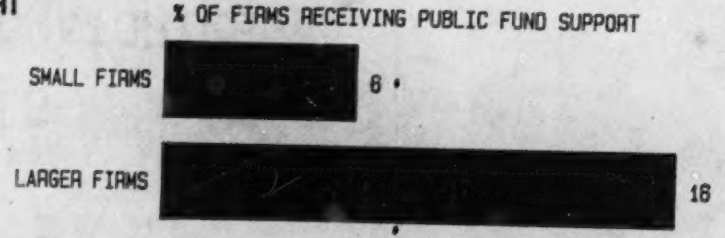
* BASIC SCIENCE
* APPLIED TECHNOLOGY
* DEVELOPMENT

SMALL FIRMS ARE NOT ONLY MORE INNOVATIVE THAN LARGER ONES BUT HAD LESS PUBLIC FUND SUPPORT

SMALL FIRMS WERE 2.5 TIMES MORE INNOVATIVE



BUT LARGER FIRMS RECEIVED 2.5 TIMES AS MUCH SUPPORT



SMALL FIRMS HAVE LESS THAN 500 EMPLOYEES
SOURCE: 1970 Comparison, Gellman Research Assoc.
Pittsburgh, Pennsylvania

RESEARCH TOPICS
1982 SBIR SOLICITATION

1. MATERIALS RESEARCH
2. ALTERNATIVE BIOLOGICAL RESOURCES
3. MARINE AND FRESHWATER RESOURCES
4. MINERAL RESOURCES
5. SCIENTIFIC AND INDUSTRIAL MEASUREMENTS
6. MICROELECTRONICS
7. COMPUTER SCIENCE AND APPLIED MATHEMATICS
8. COMPUTER ENGINEERING

RESEARCH TOPICS
1982 SBIR SOLICITATION (Cont.)

9. ROBOTICS AND CONTROLS
10. INFORMATION TECHNOLOGY
11. COMMUNICATIONS AND SYSTEMS
12. SCIENCE AND TECHNOLOGY TO AID THE HANDICAPPED
13. ADVANCED MANUFACTURING PROCESSES
14. ADVANCED CHEMICAL PROCESSES
15. CHEMISTRY
16. BIOCHEMICAL ENGINEERING

RESEARCH TOPICS
1982 SBIR SOLICITATION (Cont.)

17. IMMUNOLOGICAL AND MICROCARRIER TECHNIQUES
18. FOOD PROCESS ENGINEERING
19. WATER TREATMENT RESEARCH
20. ATMOSPHERIC TECHNOLOGY
21. RADIATION PROCESSING AND CONTROL
22. HEAT TRANSFER
23. LIGHT MACHINERY AND COMPONENTS RESEARCH
24. TUNNELING, DRILLING, EXCAVATION AND DREDGING

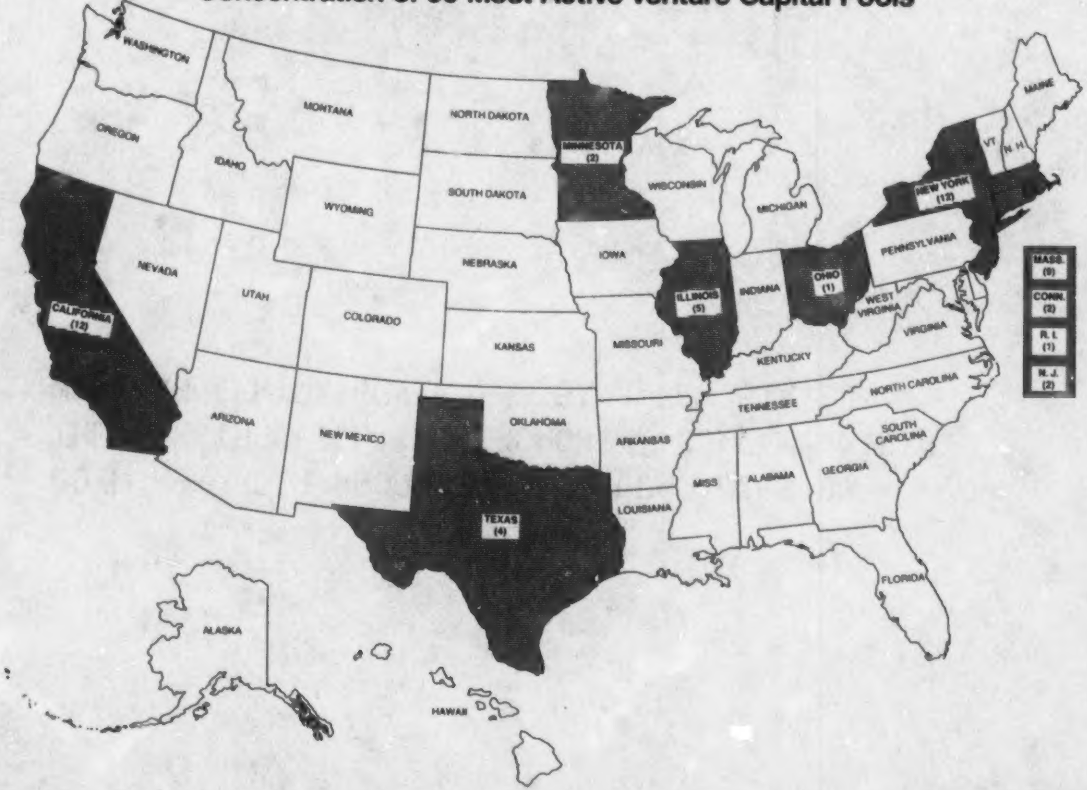
NATIONAL SCIENCE FOUNDATION SBIR PROGRAM HAS ALREADY

INVOLVED PARTICIPANTS, CONSULTANTS, GRADUATE STUDENTS FROM 30 LEADING UNIVERSITIES

MIT
BERKLEY
USC
STANFORD
CALTECH
MICHIGAN
OHIO STATE
PENNSYLVANIA STATE
RHODE ISLAND
CORNELL
UCLA
UCSB
CUNY
PENN
OREGON STATE
COLORADO STATE
IOWA
TEXAS
ARIZONA
RUTGERS
HARVARD
BRANDEIS
ILLINOIS
MISSOURI
BROWN
RIVERSIDE
BRIGHAM YOUNG
RICE
PURDUE
TEXAS A & M
MISS. STATE
UNIVERSITY OF MARYLAND

FURTHER SPREADING OF BENEFITS OF HIGH TECHNOLOGY GROWTH THROUGHOUT THE NATION

Concentration of 50 Most Active Venture Capital Pools


WASHINGTON
OREGON
CALIFORNIA (12)
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS (4)
MINNESOTA (2)
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS (5)
MICHIGAN
INDIANA
OHIO (1)
KENTUCKY
TENNESSEE
MISS
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK (12)
VT
N.H.
MAINE
MASS. (9)
CONN. (2)
R.I. (1)
N.J. (2)
ALASKA
HAWAII

BOTH NSF-SBIR PROPOSERS AND COMPANIES ON THE SIX INC. 100 "SUPERGROWTH" COMPANY LISTS WERE CONCENTRATED IN THE SAME FEW STATES

	SIX INC. SUPER GROWTH LISTS (RANK)	NSF-SBIR PROPOSALS MADE (RANK)
CALIFORNIA	1	1
NEW YORK	2	4
TEXAS	3	-
MINNESOTA	4	5
NEW JERSEY	5	6
FLORIDA	6	-
MASSACHUSETTS	8	2
MARYLAND	9	3

CONTINUED EFFORTS TO REDUCE GOVERNMENT COSTS

EXPERT SEES SMALL BUSINESS AS POTENTIAL DEFENSE COST CUTTER

WHAT IS TRUE IN DEFENSE IS TRUE IN HEALTH, HEALTH SERVICES, AND MAJOR AGENCIES

"...Schumpter was correct in describing the small entrepreneur-led company as the source of the qualitative breakthroughs in new technology that can break the monopoly of the large existing suppliers. This is the basic essence of the capitalistic system. However, in the unequal competition between the giants and the small high-technology firms it is necessary for the government (the sole buyer) to help balance the scales in order to preserve and stimulate this competition by going out of its way to assist the small R&D firms."

"...The result of all the problems at the lower tier of the defense industry has been far more sole-source business, fewer suppliers, rising prices, lengthening lead times, and a lack of production surge responsiveness. Yet, in spite of the fact that over 50 percent of all the costs for defense hardware at these lower tiers, there is essentially no government awareness of or high-level coordinated policies to address these problems."

"...More research and development at the parts-supplier levels and especially among the small high-technology firms would encourage the development of lower-cost parts, the exploitation of new technology for military advantage, greater competition, and the building up of production surge sources at the lower tiers."

Source: Gansler, J. "The Defense
Industry" pp. 156, 161

THE WHOLE SMALL BUSINESS COMMUNITY SUPPORTS
THE SMALL BUSINESS INNOVATIONS PROGRAM

National Federation of Independent Business
National Small Business Association
National Association of Small Business Investment Companies
Small Business United
National Business League
National Association of Women Business Owners
Center for Small Business-U. S. Chamber of Commerce
American Business Conference
Small Business Legislative Council
American Association of Small Research Companies

Smaller Business Association of New England
Mid-Continent Small Business United
Mountain States Small Business Council
New York State Association-Small Business Council
Council of Smaller Enterprises
Independent Business Association of Wisconsin
Smaller Manufacturers Council
Dayton Area Independent Business Council
Toledo Area Small Business Association
Cincinnati Institute on Smaller Enterprises
Independent Business Association of Minnesota
Utah Council of Smaller Business
Independent Business Association of Illinois
Chicago Association of Commerce & Industry-Small Business Council

PREPARED STATEMENT OF CLYDE R. GOODHEART, M.D., PRESIDENT, BIOLABS, INC., NORTHBROOK, ILL.

Mr. Chairman and Members of the Committee, my name is Dr. Clyde R. Goodheart. I am founder and president of BioLabs, Inc., located in Northbrook, Illinois, one of the northern suburbs of Chicago.

Briefly, my background is as follows. After finishing medical school and my internship, I took a three-year fellowship at the California Institute of Technology in cancer virology and tissue culture. My director was Dr. Renato Dulbecco, recently a Nobel Laureate. Then I did basic research in virology at the Childrens Hospital of Los Angeles for four years. When the American Medical Association Education and Research Foundation opened its Institute for Biomedical Research at its Chicago headquarters, I started and directed the laboratory for cancer virology. Our work was devoted to basic research in understanding the cancerization process. Five years later, in 1970, the AMA discontinued the Institute, and I founded BioLabs. Now, in addition to being President of BioLabs, I hold the rank of Professor, Department of Immunology and Microbiology, Rush Medical College. Recently, it has been a great pleasure for me to work with Mr. Milton Stewart, the first Chief Counsel for Advocacy, Small Business Administration, on the Task Force for Innovation by Small Business.

BioLabs is a small, independent laboratory providing services in research, product development, quality control and sterility testing, and sterile packaging. We also make and distribute products for laboratories doing tissue culture. Our work is therefore primarily in microbiology and tissue culture. Until recently, BioLabs has had at least one contract at any time for basic research for the Federal Government, through the National Cancer Institute. In addition to the Government, our clients have included many large and small companies.

My previous experience as principal investigator on grants at a University research laboratory, as the director of a laboratory at a research institute, and as the chief operating officer of a research company, have given me many opportunities to have first-hand contact with the processes funding research and the system for bringing research findings to the public. It is my belief that the Small Business Innovation Development Act (H.R. 4326 and S. 881) will have broad benefits to the public in general and that it will actually have the long-run benefit to the university research community of increasing their funding for basic research and for training scientists.

The United States is foremost in basic science among the countries of the world. We are the world leader in almost all areas of science by any measure that can be applied. Most of the Nobel Prizes are awarded to American scientists, the United States has a high percentage of working scientists, and it publishes the vast majority of the scientific journals of the world. Foreign scientists are eager to come to the United States for training or for work. Most of the fundamental new discoveries are made in the United States.

The United States is not a leader in technology, however. We either have been outpaced by or face serious challenges from foreign rivals in markets for consumer electronics and photographic equipment, ships, machine tools, office copiers, textile machinery, industrial chemicals, computers and semiconductor electronics, farm equipment, jet aircraft, automobiles, and steel. Why is it that we are such able leaders in basic science, yet we are only followers in bringing those advances in basic research to the marketplace to the benefit of the consumer?

The mechanism for bringing the results of basic science to the marketplace requires a number of steps, all of which have to work properly. When they do, we have a strong input of basic science into our everyday lives with the result that new jobs are created, we have general benefits such as better health for our citizens, longer and richer lives, less dreary jobs, better recreational opportunities, better clothing, and more nutritious food. When the mechanism breaks down, and all the different stages are not functioning properly, we see a lag in innovation with a consequent decrease in productivity. Currently, the mechanism is not functioning properly.

The first stage in the process is basic research. Although that stage is extremely good in the United States, the basic research findings and discoveries have unfortunately not yet been brought to the marketplace to the benefit of the people who paid for them. Although the university research community is the major discoverer and producer of the findings, it is not the purpose or job of the university to commercialize the new findings. That function should be performed by industry, if the return on the investment required to develop a research finding into a product or process justifies the financial risk involved.

If a company perceives some commercial possibilities in a research finding, it first must test the ideas for feasibility. If the idea has promise, it must then undertake larger expenditures to develop further data for production and design and it must build a prototype for testing. After it has a prototype and data showing that the device or process works, it can raise funds for production and marketing. Large companies have the funds to perform the entire series of steps, but they generally (with a few notable exceptions) are not accustomed to undertaking this kind of risk. Small companies are known for being willing and able to take advantage of new opportunities, but they usually do not have the risk capital available even for the feasibility study, much less for the greater expenditures required for the developing the prototype. Without the data showing the feasibility and without a prototype, they find it difficult to raise venture capital for bringing the product or process to market.

Although there are many impediments to the development of a new finding, the Bill will help to alleviate a major block. By providing the seed funds for testing feasibility of an idea in an area of need to a Federal Agency, the Agency will encourage commercialization of new findings and discoveries generated by the basic research community that is largely university-based. If one considers basic research as a product of the universities, then this bill would increase the market for that product. As the "inventory" of basic research is commercialized and "used up," the need will grow for the universities to create more. As the results of the basic research dollars spent by the taxpayers are brought back to them as new products, they will insist that funding for new research be increased. It is when basic research is done and the people who paid for it obtain no tangible benefit that they want such spending to be cut.

As companies are able to profit and grow by being able to use the basic research developed by universities, they will require more technically-trained employees. Such training is, of course, another important function of the universities. Now, one of the major employers of technically-trained people is the university community itself. Broadening the employment base is vital to our economy and would be extremely beneficial to enhancing the training function of the universities.

Dollars put into the program proposed by the Bill will create jobs and they will aid the development of new products which will produce income for the company. The flow of dollars back to the Treasury in the form of individual and corporate income taxes is likely to be many times higher than the flow back from dollars spent in other ways, many of which do not increase the tax base. The universities, as well as our economy in general, benefit from an enlargement in the tax base.

I strongly urge the passage of this bill.

Mr. STEWART. Thank you, Mr. Chairman. I could not help as I came here this morning recalling the very first assignment I had in the city of Washington having to do with small business. I was on the staff of the other body, the Senate Small Business Committee, and I remember the chairman of that committee was Senator James Murray of Montana. He was very kind, as all of you always are, to very young staff people.

I recall one day when we came off the floor of the Senate where a small business measure was being debated very hotly. We had heard a speech in opposition to the committee's recommendations from a Member of the Senate who had the day before met with us and explained to us how much he was in favor of small business.

When I came off the Senate floor, in my naive way, I said, Mr. Chairman, I do not understand. Senator so and so said yesterday that he was a devoted supporter of small business. Senator Murray, who was a very simple frontier type looked down at me, he was about 6 feet 3, and said, "You will find out that some of the people who say they are in favor of small business are in favor of making it smaller and smaller."

I could not help thinking of that as I read the statements of the critics of this legislation, every one of whom said, as he tried to devastate the legislation, that he was in favor of small business, and recognized the contributions it could make in the national interest. To outsiders, this looks like it is at about the 20-yard line. It has been a long hard pull. It goes back 6 years when the first set-aside was made in the National Science Foundation's authorization legislation.

From now on it is in the hands of the Members of the House where I believe it belongs. It is for them now to say whether the national interest will be served by this legislation, or whether the coalition against change that has been formed by the academic overhead group, the standpat procurement R. & D. specialists and a handful of people in the electronics field, is going to thwart the desires, the needs of the small business community of this country, the President of the United States, two Presidents, the Senate of the United States and certainly all the members of this committee.

I have concluded my statement, Mr. Chairman, with some brief flat statements in contradiction to the critics. I will be happy to elaborate on any of them.

I would like, by way of conclusion, to say that you have here people who really can do a job of explaining to you why the critics of this legislation are wrong far better than I can. You witnesses include those who are eminent in the academic community and who have made great contributions in the basic and applied sciences.

I would call your attention to one of the tables here which illustrates the fact and it is a fact, that 30 leading universities have been represented by faculty members and research people in the National Science Foundation program as consultants or participants in the research. I would also call your attention to what I believe is the unhealthy concentration of technology venture capital in a relatively few States.

We did a check for example of the six Inc. magazine super growth lists which we published and more than half are concentrated in the top three or four States. Those are also the States from which the most proposals come for science and technology.

I happen to be a native of one of those States and I have business and friendly relations in all of them. I believe if this becomes law many States and universities across the country will benefit from it as of New York, Texas, and other States that are leadership States in the Nation.

I will stop there and be happy to answer any questions you have.

Mr. MITCHELL. Thank you very much. I do have two questions.

One, it is reported that the American Electronics Association strongly opposes the bill. On the other hand, I have received information that position is not embraced by all the members in the American Electronics Association.

Could you comment on that? Do you have any knowledge about that?

Mr. STEWART. I do. I believe there is a witness named Mr. Terry Bibbens who represents the California Electronics Association which has several hundred small company members. I believe he will be able to tell you in detail.

I could tell you on the basis of my own knowledge. I know a fair number of small electronics company owners and managers. Those who know about this program are enthusiastically for it. You will hear from them here today and you will hear from them here in the days ahead.

Mr. **Swain**. Mr. Chairman, it seems somewhat curious to me that the people involved in this longstanding debate have only been able to highlight the opposition of one trade association, given the wide variety of trade and business associations and governmental and nongovernmental groups that have endorsed this legislation.

So whether the American Electronics Association is in favor or opposes the bill, I think is but one very, very slight factor. It disturbs me to some degree to see their opposition highlighted as much as it has been in the public press. Such highlighting is out of proportion to the level of influence it should have on these discussions.

Mr. **Mitchell**. Thank you. I will question Mr. Bibbens very closely on this because I have the very distinct impression that the members of the American Electronics Association are not unanimous in their opposition to this bill.

One other quick question. I have found an extraordinary statement being made to the effect that the bill would require the Department of Defense to set aside 26 percent of its R. & D., not 3 percent. It is an extraordinary increase and I have found no justification for that statement.

Do either of you care to comment on it?

Mr. **Stewart**. Mr. Chairman, I will try. I believe the point that critics are trying to make is that this percentage set-aside would somehow have a larger significance than would appear when it is applied to the limited funds that have not been obligated and that are totally discretionary year by year. I must tell you, sir, as someone who has been in and out of the Government six times, 3 years in the Bureau of the Budget, it is utter nonsense. It is just not true.

The degree of control and management supervision which Federal procurement offices in R. & D. have is total. They can decide where cuts have to be made within the limits set by the Congress and by the President through OMB.

Since we are talking about DOD, I commend as strongly as I can to every member of this committee, I know you do not have time to read many books, but a man named Jack Gansler wrote a book named "The Defense Industry" from which I quoted three paragraphs in the tables. He explained carefully that the expansion of small business participation in R. & D. was one of the best and most specific likely ways to reduce costs and increase efficiency in the Defense Department.

He did not single out this program because it was not then in the Defense Department. Thank goodness it is now. What he says in that book about defense is true of NIH, Health and Health Services, Energy, indeed, every large Federal agency. The larger the agency, the more true it is, the more it needs this program, and the more likely it is that its procurement officers will resist it.

Now these are the budget busting, tax eating departments of the Government. And they are in this coalition, some of their procurement people, to avoid from their standpoint the intrusion of outsiders, small business people, in the turf they have set aside for private bureaucratic sector people in large companies, universities and the like.

That is the coalition we are up against and we might as well face it.

Mr. **Mitchell**. Mr. Swain, do you care to comment?

Mr. **Swain**. I would reiterate again, Mr. Chairman, it is as I understand the position of this administration that they are fully supporting S. 881 which covers all Federal agencies having extramural research budgets in excess of $10 million. That of course includes the Department of Defense. So whether the figure is 26 percent or 2.6 percent I think is irrelevant at this point.

Mr. **Mitchell**. I thank you. I just think the 26 percent figure is ludicrous. There is just no way to explain that on any rationale basis. Mr. Smith, do you have any questions?

Mr. **Neal Smith**. Mr. Swain, I am very interested in your statement and let me just recap it and get it clear. The administration fully supports the bill without exemptions and with a 3-percent level; is that correct?

Mr. **Swain**. No; the administration as I understand it fully supports S. 881 without exemptions. Obviously the major difference as I understand it between S. 881 and H.R. 4326 is the 3 percent as opposed to the three-quarters percent in S. 881. And I am sure and confident that that can be adequately worked out as I suggested in the legislative process.

I support the 3 percent but the administration as an official matter is not willing to go on board formally supporting the 3 percent at this point.

The other aspect of the bill, the exemptions, they are definitely opposed to.

Mr. **Neal Smith**. Can you give us a little light on what percentage the administration would support?

Mr. **Swain**. I really cannot, Mr. Chairman, but I would be happy to continue to try to get some more information. I really cannot at this time.

Mr. **Neal Smith**. I just want to say, Mr. Chairman, that I think the appearance of both of these gentlemen before the committee has fully justified the setting up of the Office of Chief Counsel for Advocacy as at least a semi-independent office within the Small Business Administration.

Mr. Swain, I do not think, could come here and say as much as he did this morning if there had not been this Chief Counsel for Advocacy within the Small Business Administration. It makes it so that somebody can be a little bit separate from the administration and still promote the idea within the administration.

So I want to compliment both of you gentlemen.

Mr. **Swain**. Thank you, Mr. Smith.

Mr. **Mitchell**. Mr. Smith of New Jersey.

Mr. **Christopher Smith**. First, I want to thank you for that very strong statement and graphs. Unfortunately, since we only received this this morning I have not had a chance to review it or study it. However, in looking over your other prepared testimony, you mention that universities will benefit from this program.

Rutgers University is adjacent to my district as well as Princeton. Several people have written to me from Rutgers and Princeton indicating they were against the bill because of the money being diverted from their R. & D. and their research. Could you expand on how they will be beneficiaries?

Mr. Stewart. If you consider the interest of universities properly conceived, Mr. Smith, let's look at them one at a time. A million young people a year graduate from universities. Those people are going to need jobs. We are going to need 20.5 million jobs in the eighties; 15 million for growing population, 5.5 million to go back to work who have been laid off in this recession.

I am a father and a grandfather. I am not very happy about academic leadership that puts its overhead and its concern with basic science ahead of its concern for students. It is small business that makes 85 percent of the jobs in this country. That is where those youngsters have to find it. That is point No. 1.

Point No. 2, the alleged spokesmen for science and technology in this country are not spokesmen for it at all. They are spokesmen for the academic overhead, and I sympathize with them. They have very serious problems.

But those problems are neither made nor made worse by this legislation. The Federal Government is not the Court of the Medesty. It is not supposed to be supporting art, literature, and science for just the sake of art, literature, and science. It takes our taxpayers' money and it is supposed to do the taxpayer's business.

The people who are for this legislation in universities are the people who do the research. You will hear from them later today and I do not want to eat too much of their time.

Point No. 3. In the years ahead, the pinch on Federal expenditure will be just as hard if not harder than it has been. And the people who are in basic science with whom I sympathize totally will have to fight even harder to get money for basic science.

We will give them through this program as it expands the policy underpinning to defend basic science because we are going to strengthen the existing weak link between basic science in universities and elsewhere, and applied technology and industry which creates jobs.

They will be able to say as we can in our testimony, if you want jobs, if you want innovation, this is the road to go.

Mr. Christopher Smith. Thank you. I think your point is well taken about the basic science versus its application in the marketplace. We have in my district a great deal of R. & D. money, some of it coming from the Government. Several small business concerns, one of them I visited 2 weeks ago—the Promore Corp. which is one of the only three companies in the country developing some of the leading technology for photovoltaic cells—are saying that they are having a hard time getting the basic moneys.

The basic science is there. It just means we have got to get more money into its application. We also have fusion energy going on right next to my district. As pointed out I believe by Mr. LaFalce in his opening statement, we are seeing that that science is being scooped up by other countries that are quickly putting it into the marketplace.

While I was making a visit to the fusion reactor, there was a group from Japan, another group scheduled a few weeks later from West Germany, picking up the basic science moving ahead quickly to get it to the market. I think if small business through this bill were to receive more of that money, I think we could get it to market much quicker.

So thank you for your comments. They were well taken.

Mr. MITCHELL. Mr. LaFalce.

Mr. LAFALCE. Thank you very much, Mr. Chairman. It is a pleasure for me to be here this morning and it is a pleasure to have this hearing. I think it is opportune for us to discuss once again the issue in light of the opposition that has come to the bill since the time I reported it out of my subcommittee and it was marked up.

I ask unanimous consent that my opening statement be included as part of the record.

Mr. MITCHELL. Without objection, so ordered.

[The statement of Hon. John LaFalce follows:]

OPENING STATEMENT OF HON. JOHN J. LAFALCE, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEW YORK

It is a pleasure to join all of you at this morning's hearings on H.R. 4326, the Small Business Innovation Development Act. We certainly have heard a great deal about this important small business bill since I first chaired hearings on it in the Oversight Subcommittee last September and unanimously reported it out of the Subcommittee and Committee in October.

The bill has been criticized since then. I am glad to see us today redirecting the debate to why the Small Business Innovation Development Act is needed and the contribution it will make to the U.S. economy and U.S. technology.

Let me take a moment to discuss the need for the bill.

The U.S. economy faces today its most serious crisis since the Great Depression. Unemployment is at a postwar record. Our basic industries are collapsing. Productivity has fallen dramatically. Even the high technology sector, the one bright spot in our economy, finds it difficult to keep ahead of the Japanese, our main challenger.

Most serious of all, we are losing our ability to innovate. As the New York Times Magazine warned recently, "There are many scientific, technological and economics experts who fear that the U.S. stands on the brink of a . . . (technological) decline because the Nation's ingenuity, its ability to capitalize upon scientific findings and create a new technology that leads to new products is faltering."

We must reverse this decline and reverse it quickly if we are to prevent permanent damage to our economy and restore our ability to compete in world markets and to create the jobs essential for real prosperity.

The solution, we all know, lies with small science and high technology firms. The National Science Foundation has found that they produce 24 times as many major innovations per R&D dollar as large firms and four times as many as medium-sized firms. Moreover, they created many of the millions of new jobs that put a record number of our people to work in the last decade.

However, many small science firms find it very difficult to raise the money not only to get started but to develop their new ideas and products and then take them to the marketplace. "The money is simply not there to be had," says Ann Eskesen, Chairman of the Innovations Committee of the Smaller Business Association of New England.

Tax breaks do not help many of these small science companies that are only at the starting point. Venture capital is only available after development has reached the prototype stage. Seed money must be made available to allow firms with promising innovative ideas or products to bridge the gap between conception and birth of the idea or product. The Small Business Innovation Development Act will reverse the innovation decline and bridge the capital gap.

I want to emphasize that the approach taken by this legislation is very simple. It would require federal agencies with large R&D budgets to earmark a small percentage of the $43 billion federal R&D budget for grants to small science and high technology companies. These grants would be used for research or government projects that later could produce inventions for commercial markets. The grants would be awarded on a competitive basis and would go only to ideas of scientific and technical merit. The new program would be modeled after NSF's highly successful six-year-old Small Business Innovation Reserach (SBIR) program.

It is important for us to remember that the NSF program is deliberately used as the model. That program has the same flexibility and openness that has allowed small science firms to be so creative and productive. The results of the NSF program are impressive. The twenty-one firms that received $5 million in the first two phases of the NSF program have attracted $41 million in follow-on private capital. That translates into $8 of private investment for $1 of government investment. The grants were for such important work as laser optics research, genetics research, and research on measuring metal fracture toughness. This is just the type of leverage that is needed today to expand limited government resources.

The beauty of the Small Business Innovation Development Act is that it provides a linkage between research done in the laboratory and practical application. This linkage is called innovation. Innovation is what made the U.S. economy and U.S. technology such a powerful engine for the past century and will power us into the next century.

The main task before this Committee is to assure that a meaningful innovation bill is enacted. I look forward to the testimony at this morning's hearing and the passage shortly of the Small Business Innovation Development Act.

Mr. LAFALCE. I also want to apologize for being a bit late to a hearing of this import. It was not intentional. I flew in last night to be here on time but the only thing that would have stood in my way would have been the reapportionment process in the State of New York, and that crucial decisionmaking was taking place late last night and early this morning.

I come here with a smile on my face. I do not have any questions because I have discussed this bill both with Mr. Swain who testified previously and Mr. Stewart. I do want to take this opportunity to give special commendation to you, Milt, because were it not for your strong advocacy of this bill, were it not for the fact that Inc. Magazine, has taken this bill up as perhaps its prime cause for the small businessman this year, we would not be here today, and I do not think we would be looking to the future passage of this bill.

So my special thanks to you on behalf of the entire small business community which really we both and all represent. That is it, Mr. Chairman.

Mr. MITCHELL. Thank you. Mr. Daub.

Mr. DAUB. Thank you, Mr. Chairman.

I regret not getting here earlier to see my old friend Milt from Omaha, Nebr. It is great to see you. We are delighted you are here and to the two of you, thank you for expending the time to help in this very important legislation that is one of the keys to the reindustrialization of America.

I am really pleased with your support and advocacy. I have reviewed your testimony. I would just like to ask one question. Is it reasonable to compare the structure of this program to the small business procurement set-aside program, since both provide competition among small businesses?

Mr. SWAIN. I think that the most appropriate comparison of this program is with the existing NSF Small Business Innovation Research Program. It is a research program. It proposes a three-phase research development prototype methodology. I think the comparison to the other existing programs are inappropriate because other existing programs have other characteristics. Some are sole source programs, some of them are set-asides to one firm or one or two firms.

Within this program there is clearly competition. In fact, the small business innovation research program now existing at the NSF had more than eight applications for every award made. So this is clearly a set-aside only in the most liberal sense of the word, that it sets aside to a class of businesses.

But within that class there is going to be vigorous competition.

Mr. **Daub**. Thank you very much, Mr. Swain.

Milt, did you have anything you wanted to add?

Mr. **Stewart**. Just one quick point if I may. This has been misunderstood and I think misrepresented. There are only three institutional types that are barred from this program by the eligibility standards. A nonprofit institution because it is not oriented toward the market. A large company with over 500 employees. A Government laboratory, again because it is not market oriented.

No individual is precluded from participating in this program and that has been made perfectly clear by its history. If you are a faculty member in a university and you want to participate, it is not like other programs where your characteristics as an individual determine whether you can be in or not.

Mr. **Daub**. And you see no harm to the data program for different objectives?

Mr. **Stewart**. Different principles, different problem, different approach.

Mr. **Daub**. Does it indicate the benefits to research?

Mr. **Stewart**. No question about it. But in this case the competition I think it is fair to say is fiercer. My recollection is that the chances of getting an award began at something like 8 to 1 against. I know from people who are scientists and technical people, you will hear from some of them, that the proposals match in competence and skill of those made by anybody in the world.

Mr. **Daub**. I appreciate that very much.

Mr. Chairman, let me commend our colleague John LaFalce for his leadership in bringing this out of subcommittee to the full committee. We appreciate that and your leadership for doing what will be a landmark piece of legislation for small business.

Mr. **Mitchell**. Thank you.

Mr. Bedell.

Mr. **Bedell**. Milt, you have given us tables with your testimony. One is on Nobel Awards which is pretty clear. About three pages behind that you have a table showing Government R. & D., U.S. defense versus other goals. Is that supposed to tell the amount of government research and development for various nations?

Mr. **Stewart**. The percentage of Government R. & D. spending that goes only to defense and space. What that chart shows you is that we spend 64 percent of our Federal R. & D. dollars for defense and space. The United Kingdom spends 48 percent; France, 35 percent; Germany, 17 percent; the Japanese spend 7 percent.

Now what this means to me is that we are providing the R. & D. shield as we are other kinds of shields, and behind that shield our allies are using their Government R. & D. dollars for civilian technology research to compete with us in our own markets.

Mr. **Bedell**. I appreciate that very much. I would like to echo some of the statements that have already been made commenting the job Mr. Swain is doing. I think so clearly this indicates the need for the Chief Counsel for Advocacy and I appreciate the great leadership you have furnished in that position.

Mr. Swain, I believe you are doing a great job in that, and I think you know very well those words do not come quickly from me.

Mr. **Swain**. I appreciate all your words, Mr. Bedell.

Mr. **Bedell**. Since the Reagan administration came in I have been looking for something I could support them in. I am delighted to have finally found something that we agree on. I have been on the losing side on every one of those previous issues. I am sure that now we are together there is no question about our prevailing.

Mr. **Swain**. Just think of it as a toehold, Mr. Bedell.

Mr. **Mitchell**. Mr. Roemer.

Mr. **Roemer**. Yes, thank you, Mr. Chairman.

I want to thank the gentlemen for their testimony and say that I have a feeling that most members of this committee support this legislation, not for what it does for small business, but for what small business does for our economy.

Mr. **Stewart**. Absolutely.

Mr. **Roemer**. I thank both of you for making that point clearly. My question has to do with something I picked up from a comment you made, Mr. Swain. I want to make sure I understand it for the record.

What changes, if any, in H.R. 4326 are you suggesting? What reservations, if any, about the present bill do either or both of you have?

Mr. **Swain**. I do not personally have any reservations at all about H.R. 4326. I felt that it was important, since the last time that the administration had been heard from on this legislation was before it had gone through several committees and had undergone several different proposed amendments.

I touched base with the people in the Office of Management and Budget to try to ascertain their official position at this point. They advised me that they were standing steadfastly behind S. 881 and that there were some changes that had been proposed that were departures from S. 881, that it was clearly not their intention to support.

We are specifically talking about the action of several committees in exempting major agencies. My understanding is that the major difference at this point between S. 881 and H.R. 4326 is the percentage of set-aside. I cannot sit here today and tell you what I think the happy medium is on that, but I am sure that is a point that can be worked out to the satisfaction of all parties concerned.

Mr. **Roemer**. So it is the threshold basically.

Mr. **Swain**. That is my understanding to the best of my knowledge, Mr. Roemer.

Mr. **Roemer**. Thank you.

Mr. Stewart, any comment as to reservations or——

Mr. **Stewart**. Not really, Mr. Roemer. I honestly think we are at a point where this is best left to the Members of the House to work out among themselves. As a general principle, I think the more Federal agencies that have the opportunity to experience this program and find out about it, the better. I think that is without a doubt the case.

I think the proposed buildup of commitment is reasonable. The end amounts, I think, we will all wind up being in agreement about when we see what the program does over a 5-year period.

I have every confidence that the responsible leaders in both parties will find ways to accommodate the needs of everybody.

Mr. **Roemer**. Very good. I thank you, Mr. Chairman.

Mr. **Mitchell**. I want to thank both of you gentlemen. It has been a pleasure to have heard your testimony and work with you as we have done over the past years, in your case, Milt, and more recently with you, Mr. Swain.

Thank you very much for being here.

Without objection, at this point in the record we will insert 3 studies on small business and innovation which originated with the Office of Chief Counsel for Advocacy.

[The studies referred to above follow:]

Gellman Research Associates, Inc.

THE RELATIONSHIP BETWEEN INDUSTRIAL CONCENTRATION, FIRM SIZE, AND TECHNOLOGICAL INNOVATION

FINAL REPORT

May 11, 1982

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EXECUTIVE SUMMARY

The process of innovation is a subject of increasing interest and significance, and it is of special interest to those seeking to stimulate or support innovative activity. In this context, it is important to understand the relationships that exist between an innovating unit and the environment in which it operates. The desire to add to this understanding provided the impetus for initiating the research reported here.

This research focused on relationships between an innovating firm, and the industry of which it is a member, and innovative performance, with special emphasis on firm size. Industry characteristics singled out for study were concentration, growth, and capital intensity. The measures of innovation performance were the frequency of innovation and the speed at which innovation occurs.

All of the data on innovation performance were collected by Gellman Research Associates (GRA) either as part of this study or an earlier study commissioned by the National Science Foundation (NSF). Unlike many previous studies which employ proxies for innovative behavior, such as patented inventions or research and development (R&D) expenditures, the present effort examines in detail actual innovations brought to market. A total of 635 innovations were studied including 45 from the NSF study. To this information was added data on firm size, concentration, industry growth, and industry capital intensity from various published sources. The data set was then used to examine various relationships.

The principal findings are:

1. Small firms produce 2.5 times as many innovations as large firms, relative to the number of people employed.
2. Small firms bring their innovations to market faster than large firms.
3. Large firms are 2.8 times more likely to be assisted in innovation by public funds.
4. Large firms in concentrated industries tend to acquire more of their innovations from other firms than do smaller companies.
5. Small-firm innovation rates based on employment are below the small firm average in diffuse industries (Concentration Ratio ≤ 0.2) and significantly above average in industries with $0.2 < CR \leq 0.4$.

6a. In industries where ~~employment~~ is increasing, large firms in highly concentrated industries ($0.6 < CR \leq 1.0$) innovate below the average of large firms in growing industries and above average for ($0.2 < CR \leq 0.6$).

6b. In industries where employment is decreasing, large firms in less concentrated industries ($CR \leq 0.4$) innovate above the average of large firms in declining industries and below average elsewhere.

7. Small and large firms exhibit substantially the same distributions of innovation with respect to concentration ratio. The intervals $0.2 < CR \leq 0.6$ in industries with increasing employment and $0 < CR \leq 0.4$ in industries with decreasing employment are the major producers of innovation.
8. Innovation performance by small firms is not affected by capital intensity.
9. Large firms innovate less in capital-intensive industries than in industries that are not capital intensive.

These principal findings have significant policy implications, including the following:

- The finding that small firms produce significantly more innovations than large firms per employee, coupled with earlier findings that small firms are more efficient in their use of R&D dollars,* indicates that public R&D funding of small technologically-aware firms will be significantly more cost-effective than the funding of larger firms.
- The cost-effectiveness of public funding of small firm R&D is further enhanced because small firm innovations are brought to market sooner than those of large firms.

Other findings are discussed in detail in the report.

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*Science Indicators 1976, Report of the National Science Board 1977, p. 116-118.

Chapter 1

INTRODUCTION AND FINDINGS

I. Introduction

The process of industrial innovation is a subject of increasing interest and significance, and it is of special interest to those seeking to stimulate or support innovative activity. In this connection, it is important to understand the relationships that exist between an innovating unit and the environment in which it operates. The desire to add to this understanding provided the impetus for initiating the research reported here.

The focus of this research is on relationships between an innovating firm and the industry of which it is a member and innovation performance. Special emphasis was given to the role of firm size as it affects the propensity of a firm to innovate. Industry characteristics singled out for study were concentration, growth, and capital intensity. The measures of innovation performance were the frequency of innovation and the speed at which innovation occurs.

Inquiries were also made into how and to what extent public funding enters the innovation process, including the marketing and distribution of innovations, and into the effect of successful innovation on the ownership of an innovating firm.

This study is one of several recent efforts to add to the store of knowledge and to further understanding of this subject. To the extent that the data collection techniques employed are similar, it is an extension of an earlier National Science Foundation study[1] of 500 innovations introduced between 1953 and 1973. Unlike many previous studies which employ proxies for innovating behavior, such as patented inventions or R&D expenditures, the present effort examined in detail actual innovations brought to market.

Of the 500 innovations reported in the NSF study, 277 were introduced by United States manufacturing firms and, of these, 45 were introduced after 1969. Data on these 45 innovations were combined with the data of the present study.

This study examines the effect on innovation performance of the following:

- industry concentration,
- industry captial intensity,
- firm size,
- markets for innovations,
- public funding of the innovation process,
- ownership of innovating firms,
- the effect of innovation upon ownership, and
- transfer of product innovations abroad.

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[1] Indicators of International Trends in Technological Innovation, Washington, DC: National Science Foundation, 1976.

These questions were based on previous theoretical and empirical work on the relationships between innovation performance and firm and industry characteristics. One theory hypothesizes that highly concentrated industries should be more willing and able to undertake the process of innovation, a priori. This may be so if the process of innovation is costly and/or risky. By using their market power to attain higher profit levels, firms may be able to generate significant internal pools of funds which allow them to invest in relatively risky R&D without having to obtain capital from external sources.

Other theories concerning the beneficial effects of concentration on innovations include the following. Companies that are not subject to the short-run uncertainties of competition may be more willing to commit funds to long-range R&D projects. Moreover, monopolistic or oligopolistic firms may be better able to internalize the benefits from innovation through their more extensive distribution and marketing channels. Finally, because oligopolists often do not compete on a price basis, they may place more emphasis on non-price dimensions of competition such as product differentiation and innovation.

On the other hand, it has been hypothesized that firms in competitive industries have a greater incentive to innovate precisely because of the competitive nature of the market. (A small firm has more to gain from innovation.) A corollary to this view is that a high degree of market power breeds complacency and creates institutional barriers to change. This point of view engenders the hypothesis that firms with considerable market power will innovate more slowly, but may be aggressive followers or imitators of smaller firms once the latter have completed the innovation process.

However, any attempt to test the above hypotheses requires that absolute firm size be distinguished from industry concentration (corresponding to some measure of market power). The above hypotheses have been cast in terms of industry concentration, but parallel arguments can be offered concerning the relationship between absolute firm size and innovation.

Specifically, it can be argued that large firms are better able to innovate because of their larger pool of financial resources. Conversely, those who believe that a small firm environment favors innovation would argue that increasing firm size leads to institutional inertia, thus slowing the desire to innovate.

Although the arguments concerning absolute firm size and industry concentration as they relate to innovation are somewhat parallel, it should be clear that the hypotheses themselves are quite distinct. Thus, for example, a result indicating that firms in competitive industries tend to innovate more than firms in concentrated industries does not, by itself, imply a relationship between firm size and innovating efficiency.

Because data on R&D expenditures per employee were not collected as part of this study, a direct comparison of innovative performance between small and large firms with respect to R&D expenditures is not possible. On the other hand, a finding that small firms innovate at a greater frequency than large firms, based on the number of persons employed, would be consistent with earlier research which showed that small firms (less than 1,000 employees) produce about 4 times as many innovations as large firms per R&D scientist and engineer and that the cost per R&D scientist and engineer is almost twice as great in firms with over 1,000 employees than in firms with less than 1,000 employees.[2] A small firm in the present study is defined as a firm with less than 500 employees.

II. Principal Findings and Policy Implications

The detailed analyses leading to the findings of the study are given in Chapter 3. The principal findings are the following:

1. Small firms produce 2.5 times as many innovations as large firms, relative to the number of people employed.
2. Small firms require less time to take an innovation from performance specification to market introduction.
3. Large firms are 2.8 times more likely to be assisted in innovation by public funds.
4. Large firms in concentrated industries tend to acquire more of their innovations from other firms than do small firms.
5. Small-firm innovation rates based on employment are below the small firm average in diffuse industries (Concentration Ratio ≤ 0.2) and significantly above average in industries with $0.2 < CR \leq 0.4$.

---

[2] Small Firms and Federal R&D, 1977, Office of Management and Budget.

6a. In industries where employment is increasing, large firms in highly concentrated industries innovate below the average of large firms in growing industries ($0.6 < CR \leq 1.0$) and above average for ($0.2 < CR \leq 0.6$).

6b. In industries where employment is decreasing, large firms in less concentrated industries ($CR \leq 0.4$) innovate above the average of large firms in declining industries and below average elsewhere.

7. Small and large firms exhibit substantially the same distributions of innovation with respect to concentration ratio. The intervals $0.2 < CR \leq 0.6$ in industries with increasing employment and $0 < CR \leq 0.4$ in industries with decreasing employment are the major producers of innovations.

8. Innovation performance by small firms is not affected by capital intensity.

9. Large firms innovate less in capital-intensive industries than in industries that are not capital intensive.

Interpretation of Findings

One must proceed with caution in attempting to draw further inferences by combining two or more findings. For example, consider the following figure:

Innovation Performance of Large Firms

	Capital-Intensive Industry	Non-Capital Intensive Industry	Average Innovation Performance
Concentrated Industry	?	?	Below
Diffuse Industry	?	?	Above
Average Innovation Performance	Below	Above	

None of the relationships in the "boxes" shown above were explicitly tested. However, the results labeled "Average Innovation Performance" were tested. For example, large firms innovate less in concentrated industries than in diffuse industries. This finding, however, cannot be used to draw a conclusion about the innovation performance of large firms in either capital-intensive concentrated industries or non-capital-intensive concentrated industries.

Implications

The principal findings of the present study have unambiguous implications for public policy towards small businesses. First, the finding that small firms produce significantly more innovations than large firms per employee indicates that public R&D funding of small technologically-aware firms will be more cost-effective than the funding of large firms. The public benefits further from the fact that small firms bring their innovations to market sooner than large firms. However, the study indicates that large firm innovations are more likely to be assisted by public funds.

The results of this study support a conclusion that small firms more than carry their weight in terms of producing innovations and therby add to the technological and economic progress of the United States. Increased public funding of such firms for innovative activities should therefore be encouraged.

III. Analysis

The industries generating the innovations reported in the survey are not homogeneous. Among other things, they vary with respect to growth, firm size, concentration, capital intensity, the age of their technological base, and the characteristics of their markets. These variables were used to partition the survey data into subsamples for further analysis.

One such partitioning reflects, in an approximate way, the familiar life cycle concept of product and industry develoment, with its stages of product introduction, market expansion, market stability, and finally, decline. The criteria for grouping the industries were formulated in terms of the changes in the number of establishments and the number of employees in an industry over a specified time interval.

Four groups, denoted by P1, P2, P3, and P4, were defined. Their definitions are given in Table 1.1, together with the number of innovating industries in each group and the number of innovations produced.

Table 1.1

DISTRIBUTION OF INDUSTRIES AND INNOVATIONS WITH RESPECT TO CHANGES IN NUMBER OF EMPLOYEES AND NUMBER OF ESTABLISHMENTS

P1: Establishments Increased or Data Not Available for 1967
Employment Increased
Industries: 57
Innovations
Small Firms: 121
Large Firms: 207
Unknown: 50

P2: Establishments Increased or Data Not Available for 1967
Employment Decreased
Industries: 42
Innovations
Small Firms: 89
Large Firms: 109
Unknown: 21

P3: Establishments Decreased
Employment Increased
Industries: 6
Innovations
Small Firms: 2
Large Firms: 7
Unknown: 0

P4: Establishments Decreased
Employment Decreased
Industries: 16
Innovations
Small Firms: 14
Large Firms: 14
Unknown 1

The data for determining changes in the number of establishments and employment are shown in Appendix C. These data were obtained from the United States Department of Commerce, Census of Manufactures.

Changes in the number of establishments were developed by comparing the number of industry establishments in 1972 with those in 1967. Changes in employment were obtained by comparing industry employment in 1976 with employment in 1967. Where 1967 employment figures were not available (NA), the comparison was made between 1976 and 1972 figures. Details are given in Chapter 3.

Industries in P1 are growing in terms of both number of establishments and employment; typically, these are newer industries in the sense that they either employ recently introduced technologies or compete in new markets, whether or not these markets were created by or exist independently of the new technology. In contrast, industries in P4 are in decline in terms of both employment and number of establishments; these industries typically employ old or developed technologies and compete in established but declining markets. Industry groups P2 and P3 are intermediate cases.

One might expect P1 industries to be more innovative than P2, P3, or P4 industries. This is illustrated in Table 1.2 which shows the frequency of innovations produced by industries for which ten or more innovations were reported in the survey. Appendix D provides additional details on the industries in each subsample.

Table 1.2

DISTRIBUTION OF INNOVATIONS AMONG INDUSTRIES REPORTING TEN OR MORE INNOVATIONS

SIC Number	Industry Description	Population	Total
2821	Plastics, Synthetic Resins, and Nonvulcanizable Elastomers	P1	18
3079	Miscellaneous Plastics Products	P1	10
3551	Food Products Machinery	P1	10
3573	Electronic Computing Equipment	P1	32
3674	Semiconductors and Related Devices	P1	23
3714	Motor Vehicle Parts and Accessories	P1	18
3825	Instruments for Measuring and Testing of Electricity and Electrical Signals	P1	44
3829	Measuring and Controlling Devices, NEC	P1	26
3832	Optical Instruments and Lenses	P1	68
3861	Photographic Equipment and Supplies	P1	13
3545	Machine Tool Accessories and Measuring Devices	P2	16
3569	General Industrial Machinery and Equipment, NEC	P2	12
3662	Radio and Television Transmitting, Signaling, and Detection Equipment and Apparatus	P2	32
3811	Engineering, Laboratory, Scientific, and Research Instruments and Associated Equipment	P2	41
3823	Industrial Instruments for Measurement, Display, and Control of Process Variables	P2	33
3541	Machine Tools, Metal Cutting Types	P4	10

Chapter 2

DATA COLLECTION

I. Selection of Innovations

GRA compiled a sample of 590 innovative products in selected industries. The objectives of the sample selection process were as follows:

- to obtain a sample of innovations which, when combined with data from the NSF study on 45 innovations introduced after 1969, would be large enough to permit significant inferences to be drawn from an analysis of the innovation process;
- to represent innovations from the broad spectrum of industries as measured by concentration, growth rate, and capital intensity;
- to represent adequately innovations introduced by both large and small firms; and
- to concentrate on innovations marketed in the U.S. since 1970.

The sample served to identify a set of innovations for which basic information was available and which met the objectives listed above.

The sources of the sample are the publications listed in Table 2.1. Approximately 43 percent of the sample was selected from among the award-winning innovations described in Industrial Research & Development Magazine. The publication spans the period 1970-1979.

Table 2.1

SOURCES OF SAMPLE

Source Publication	Number of Innovations	Percentage of Total
Automotive Engineering	16	2.7
Aviation Week & Space Technology	2	0.3
EDN Magazine/Electrical Design News	14	2.4
Engineering Newsrecord	17	2.9
Food Engineering	32	5.4
IEEE Spectrum	21	3.6
Industrial Research & Development	252	42.7
Mechanical Engineering	8	1.4
Modern Plastics	14	2.4
Optical Engineering	17	2.9
Product Engineering	72	12.2
Review of Scientific Instruments	44	7.5
Tooling & Production	47	8.0
Ward's Auto World	23	3.9
Other	11	1.9
Total	590	100.0 %

Articles and advertisements in the source publications were surveyed to identify products or processes that had been offered for sale in the marketplace and which incorporated some aspect of technical change. From the reference in the periodical, basic information about the product was recorded, including a description of the innovation, the identity of the innovating company, the date of market introduction, and the source publication. The data form used to record this information is reproduced as Figure 2.1. The process of identifying and selecting innovations for a sample is similar to that used in an earlier study of innovation prepared by Gellman Research Associates, Inc. for the National Science Foundation.[3]

The periodicals surveyed were selected for their coverage of seven product areas that had been well-represented in the earlier NSF study. Three areas were chosen from among relatively concentrated industries, and four from relatively competitive industries. By this procedure, GRA sought to insure that the sample incorporated a sufficient number of innovations in each type of industry to support inferences about industry structure and innovation. The three relatively concentrated industries were defined by the Standard Industrial Classification[4] (SIC) Group Numbers 357 (Office, Computing and Accounting Machines); 371 (Motor Vehicles and Motor Vehicle Equipment); and

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[3] Indicators of International Trends in Technological Innovation, Washington, DC: National Science Foundation 1976.

[4] Executive Office of the President, Office of Management and Budget, Standard Industrial Classification Manual, 1972. Washington, DC: GPO.

Figure 2.1

Innovation No. ________
Inncyation Rank ________
Preliminary No. ________

INNOVATION DATA FORM

PART I: DESCRIPTIVE DATA

1. Description of the Innovation: ________

2. Innovating Organization: ________
Name: ________
Address: ________
Telephone: ________
SIC Number or Product Lines (If Known): ________

3. Date of Market Introduction: ________

4. Country of Market Introduction: United States

5. Source: ________

Form 11/30/79 Signature: ________ Date Completed: ________

386 (Photographic Equipment and Supplies). The four relatively more competitive industries were defined by SIC Group Numbers 307 (Miscellaneous Plastics Products); 354 (Metalworking Machinery and Equipment); 355 (Special Industry Machinery, except Metalworking Machinery); and 383 (Optical Instruments and Lenses).

Collection of the Sample

The sample that resulted from this selection process represented a broader range of products than the seven areas originally chosen for emphasis. One reason is that products serving an industry come from a diversity of sources, including other industries that provide components and supplies. In addition, technologies developed in one industry may be applied to the products of numerous other industries. For example, many of the innovations in the machine tool industry involve numerical control equipment based on electronic and computer technologies.

The range of industries introducing innovations reported in the sample, including 45 post-1969 innovations from the NSF study, is shown in Table 2.2. A four-digit SIC number was assigned to each innovation on the basis of its characteristics as a product. In the hypothetical case of a laser alignment device for machine tools, for example, the SIC number assigned would be 3545, which covers machine tool accessories. At a later point in the study, the SIC numbers of the industry that first introduced the innovation would be assigned; in the case of a laser alignment device, it could have been a computer company, an electronics firm, or an organization in some other industry.

Table 2.2

DISTRIBUTION OF SAMPLE, BY 3-DIGIT SIC CODE*

SIC No.	Frequency	SIC No.	Frequency
205	1	347	3
222	1	349	11
229	1	352	2
239	1	353	9
249	1	354	39
251	1	355	20
264	1	356	22
266	1	357	38
281	8	358	4
282	24	359	2
283	1	361	3
284	2	362	8
285	2	363	1
286	2	364	4
287	2	365	1
289	10	366	36
301	1	367	41
307	10	369	16
322	2	371	21
325	1	372	2
326	1	373	1
327	1	375	2
329	5	381	43
331	3	382	114
332	1	383	68
335	2	384	7
339	1	385	2
341	1	386	13
342	1	387	1
343	2	395	1
344	4		
345	4		
346	1		

---

*Includes 45 post-1969 innovations from NSF study.

II. Collection of Survey Data*

More detailed and accurate information was obtained for a subset of the sample. Beginning with the company identified in the source publication from the sample, telephone interviewers attempted to locate people familiar with the history of the product, its development, and its marketing. These individuals may have participated in the innovation process at any of several stages and in various roles. Occasionally, several individuals contributed information about the development of a single innovation. The telephone inquiries, together with mailed questionnaires where necessary, proved to be a highly efficient means of locating and obtaining information about the development of a product and the innovating organization. Typically, this kind of information is not available from public sources or corporate records.

The information sought in the telephone/mail survey is described in Part II of the Innovation Data Form (Figure 2.2). These data were obtained for a subsample of innovations. (Firm size information was obtained for another 314 innovations.) The size of the subsample was limited by the following causes:

- inability to locate the innovating company or individuals,
- refusal by a company to participate in the survey, or
- failure to substantially complete the questionnaire.

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*Excludes 45 NSF innovations.

Figure 2.2

GELLMAN RESEARCH ASSOCIATES, INC.

PART II: DETAILED INNOVATION HISTORY

A. History of Product (or Process) Development

1. Identify and date key elements in the preproduction stage:

Key Element	Date	Not Known	Not Applicable	No Response	Question Omitted
(a) performance criteria					
(b) preliminary engineering designs finalized					
(c) prototype/pilot-project/ bench model					

2. Identify and date key elements in the production and marketing of the innovation:

Key Element	Date	Not Known	Not Applicable	No Response	Question Omitted
(a) first production					
(b) meet government regulation					
(c) first order/contract/ delivery					
(d) modifications after first delivery (required by customer)					
(e) start-up sales promotion					
(f) first retail sales					

Figure 2.2 (Cont'd)

B. Technology

3. Was any part of the technology underlying the innovation:

(a) developed by R&D activity within the organization?

_____ Yes _____ Not Known _____ No Response
_____ No _____ Not Applicable _____ Question Omitted

(b) acquired through merger or acquisition of a going concern?

_____ Yes _____ Not Known _____ No Response
_____ No _____ Not Applicable _____ Question Omitted

(c) developed abroad?

_____ Yes _____ Not Known _____ No Response
_____ No _____ Not Applicable _____ Question Omitted

(d) acquired by license?

_____ Yes _____ Not Known _____ No Response
_____ No _____ Not Applicable _____ Question Omitted

(e) patented (by this organization or another)?

_____ Yes _____ Not Known _____ No Response
_____ No _____ Not Applicable _____ Question Omitted

(f) Was the technology acquired in any other way not mentioned above?

_____ Yes _____ Not Known _____ No Response
_____ No _____ Not Applicable _____ Question Omitted

If yes, please specify: ____

____

____

Figure 2.2 (Cont'd)

C. Governmental Role

4. (a) Were public funds, contracts, grants, etc., used to assist the innovating enterprise?

_____ Yes
_____ No
_____ Not Known
_____ Not Applicable
_____ No Response
_____ Question Omitted

(b) If yes, which specific activities related to innovation did public funds support?

_____ Basic Research
_____ Applied Research
_____ Development
_____ Engineering
_____ Production-Oriented Activities
_____ Marketing and Distribution
_____ Other (specify) __________
____
_____ Not Known
_____ Not Applicable
_____ No Response
_____ Question Omitted

D. The Innovating Organization

5. Describe the type of organization you are (e.g., retail, industrial, wholesale, farm, research institution, university): __________
____

_____ Not Known
_____ Not Applicable
_____ No Response
_____ Question Omitted

6. What is the present size of the organization (no. of employees)?

_____ 0
_____ 1-9
_____ 10-19
_____ 20-99
_____ 100-249
_____ 250-499
_____ 500-999
_____ 1000+

Figure 2.2 (Cont'd)

6. If only a rough approximation is possible:
(cont.)

_____ 0 _____ 500-999
_____ 20-99 _____ 1000+
_____ 100-499

_____ Not Known _____ No Response
_____ Not Applicable _____ Question Omitted

7. (a) When the innovation was introduced, was the size of the organization very different?

_____ Yes _____ Not Known _____ No Response
_____ No _____ Not Applicable _____ Question Omitted

(b) If yes, how many employees did it have?

_____ 0 _____ 100-249
_____ 1-9 _____ 250-499
_____ 10-19 _____ 500-999
_____ 20-99 _____ 1000+

If only a rough approximation is possible:

_____ 0 _____ 500-999
_____ 20-99 _____ 1000+
_____ 100-499

_____ Not Known _____ No Response
_____ Not Applicable _____ Question Omitted

8. Describe the organization's present form of ownership.

_____ Closely held corporation, partnership or sole proprietorship
_____ Publicly held corporation (shares traded on exchange)
_____ Government-owned or controlled

_____ Not Known _____ No Response
_____ Not Applicable _____ Question Omitted

Figure 2.2 (Cont'd)

9. (a) Was the form of ownership different when the innovation was introduced?

_____ Yes	_____ Not Known	_____ No Response
_____ No	_____ Not Applicable	_____ Question Omitted

(b) If yes, describe the previous form of ownership:

_____ Closely held
_____ Publicly held
_____ Government-owned or controlled

_____ Not Known	_____ No Response
_____ Not Applicable	_____ Question Omitted

10. (a) At the time of market introduction, was the innovative product the firm's only product?

_____ Yes	_____ Not Known	_____ No Response
_____ No	_____ Not Applicable	_____ Question Omitted

(b) Is the innovative product now the firm's only product?

_____ Yes	_____ Not Known	_____ No Response
_____ No	_____ Not Applicable	_____ Question Omitted

(c) Was the innovative product the first product in what later became a broad line?

_____ Yes	_____ Not Known	_____ No Response
_____ No	_____ Not Applicable	_____ Question Omitted

E. Market Information

11. What product(s)/types of product(s) do you sell (in general)? ______________________________

____

____

____

_____ Not Known	_____ No Response
_____ Not Applicable	_____ Question Omitted

Figure 2.2 (Cont'd)

12. To whom do you sell this product: To what types of organizations? (producers, distributors, consumers, government organizations, or users internal to your organization).

____

____

____

_____ Not Known
_____ Not Applicable
_____ No Response
_____ Question Omitted

13. Was the innovative product introduced into a market not previously served by the innovating organization?

_____ Yes
_____ No
_____ Not Known
_____ Not Applicable
_____ No Response
_____ Question Omitted

14. (a) Was the innovative product sold abroad before it was introduced in the U.S.?

_____ Yes
_____ No
_____ Not Known
_____ Not Applicable
_____ No Response
_____ Question Omitted

(b) If yes, was it sold abroad by you or by another company? ____________________

15. Has the product been sold abroad since it was introduced in the U.S.?

_____ Yes
_____ No
_____ Not Known
_____ Not Applicable
_____ No Response
_____ Question Omitted

Figure 2.2 (Cont'd)

Section F

16. Further comments: ____________________

17. Sources of information (please list the key sources of information provided in the survey). Where possible, associate the source with the item number on the form: ____________________

25 Part II Completion Date: ____________ Signature: ____________

The distribution of innovations for the industries represented in the subsample is shown in Table 2.3. It should be noted that Table 2.3 includes the 45 NSF innovations.

Summaries of the survey data for the 206 questionnaires are presented in Appendix A. Similar data on the 45 post-1969 NSF innovations are given in Appendix B. The summaries profile the responses to the survey questions. In referring to these data, it should be noted that the distributions of time series data are given both with respect to the year in which an event (e.g., prototype developed) occurred and with respect to the elapsed time between the event and the introduction of the innovation to the market.

In testing a hypothesis, the maximum amount of data available for that test was used. Thus, the sample for testing hypotheses on the effect of concentration included all innovations for which firm size was available. Other questions could only be examined with respect to those innovations for which Part II of the Data Form was complete.

III. Collection of Industry Data

While the telephone survey provided valuable information for individual innovations and firms, it was necessary to obtain additional industry-specific data on the number of establishments, employment, concentration, and capital intensity. These data were needed to develop statistical tests on the relationship between innovation behavior and three industry characteristics: concentration, capital intensity and growth.

Table 2.3

DISTRIBUTION OF INNOVATIONS BY 3-DIGIT SIC CODE BASED ON QUESTIONNAIRE*

SIC No.	Frequency	SIC No.	Frequency
205	0	347	3
222	1	349	4
229	0	352	0
239	1	353	4
249	0	354	8
251	0	355	6
264	1	356	8
266	0	357	24
281	7	358	0
282	12	359	0
283	1	361	2
284	2	362	4
285	0	363	1
286	1	364	1
287	2	365	0
289	4	366	16
301	0	367	16
307	7	369	7
322	1	371	13
325	1	372	2
326	0	373	0
327	0	375	0
329	1	381	13
331	1	382	37
332	0	383	24
335	0	384	4
339	0	385	2
341	0	386	6
342	0	387	0
343	1	395	0
344	1		
345	1		
346	1		

---

*Includes 45 post-1969 innovations from NSF study.

The measure of concentration used was the 4-firm concentration ratio by value of shipments in the 1972 Census of Manufactures[5] for 4-digit SIC industry groups.

Capital intensity was defined as gross stocks per employee, where gross stocks represent capital assets on hand adjusted for discards of worn-out assets. Data on gross stocks were obtained from the capital stock data base compiled by the Bureau of Labor Statistics in the U.S. Department of Labor. These data are available, with few exceptions, only at 3-digit SIC level; correspondingly, 3-digit employment data were used to calculate capital intensity.

A Growth Rate for each 4-digit industry was defined as:

$$\text{Annual Growth Rate} = \frac{(\text{1976 Employment}) - (\text{1967 Employment})}{9.0 \times (\text{1967 Employment})}$$

In industries where 1967 employment data were unavailable, 1972 employment was used instead, and the comparable estimate is:

$$\text{Annual Growth Rate} = \frac{(\text{1976 Employment}) - (\text{1972 Employment})}{4.0 \times (\text{1972 Employment})}$$

The data on establishments, employment, concentration, capital intensity, and growth are given in Appendix C. Data on establishment employment by size of owning company are given in Appendix E.

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[5] U.S. Department of Commerce, Bureau of the Census, 1972 Census of Manufacture, Vol. 1, Subject and Special Statistics, Table 4. Washington, DC: GPO, 1976.

Chapter 3

DATA ANALYSIS

I. Introduction

The industries generating the innovations reported in the survey are not homogeneous. They vary with respect to growth, firm size, concentration, capital intensity, the age of their technological base, and the characteristics of their markets. These variables were used to partition the sample into subsamples for further analysis.

Of the 121 industries represented in the survey, 70 industries showed an increase in the number of establishments from 1967 to 1972, 22 showed a decline in the number of establishments and 29 did not have data available on the number of establishments for 1967.

Four industry groupings denoted by P1, P2, P3, and P4, were defined as follows:

- P1--Establishments increased or data not available for 1967
  Employment increased
- P2--Establishments increased or data not available for 1967
  Employment decreased
- P3--Establishments decreased
  Employment increased
- P4--Establishments decreased
  Employment decreased

Table 3.1 shows the number of industries and the distribution of innovations by firm size within P1, P2, P3, and P4. Tables 3.2 and 3.3 show the distribution of innovations and employment in P1, P2, P3, and P4 with respect to concentration ratio and firm size.

Table 3.1

DISTRIBUTION OF INDUSTRIES AND INNOVATIONS IN THE SUBSAMPLES P1, P2, P3, AND P4

P1:	Industries	57
	Innovations	
	Small Firms	121
	Large Firms	207
	Unknown	50
P2:	Industries	12
	Innovations	
	Small Firms	89
	Large Firms	109
	Unknown	21
P3:	Industries	6
	Innovations	
	Small Firms	2
	Large Firms	7
	Unknown	0
P4:	Industries	16
	Innovations	
	Small Firms	14
	Large Firms	14
	Unknown	1

Table 3.2

DISTRIBUTION OF INNOVATIONS AND EMPLOYMENT WITH RESPECT TO CONCENTRATION RATIO FOR SMALL FIRMS*

INNOVATIONS

Concentration Ratio	Subsample P1	 P2	 P3	 P4	Total
$0 \le CR \le 0.2$	17	31	1	0	49
$0.2 < CR \le 0.4$	41	46	0	11	98
$0.4 < CR \le 0.6$	56	7	1	3	67
$0.6 < CR \le 0.8$	7	2	0	0	9
$0.8 < CR \le 1.0$	0	3	0	0	3
	121	89	2	14	226

EMPLOYMENT (1000)

Concentration Ratio	Subsample P1	 P2	 P3	 P4	Total
$0 \le CR \le 0.2$	421	160	15	-	596
$0.2 < CR \le 0.4$	153	134	13	145	445
$0.4 < CR \le 0.6$	161	76	4	17	258
$0.6 < CR \le 0.8$	78	4	-	10	92
$0.8 < CR \le 1.0$	3	4	1	0	8
	816	378	33	172	1399

---

*Includes 45 NSF cases

Table 3.3

DISTRIBUTION OF INNOVATIONS AND EMPLOYMENT WITH RESPECT TO CONCENTRATION FOR LARGE FIRMS*

INNOVATIONS

Concentration Ratio	Subsample				
	P1	P2	P3	P4	Total
0 ≤ CR ≤ 0.2	21	42	0	0	63
0.2 < CR ≤ 0.4	74	43	1	7	125
0.4 < CR ≤ 0.6	82	17	5	0	104
0.6 < CR ≤ 0.8	29	4	0	5	38
0.8 < CR ≤ 1.0	1	3	1	2	7
	207	109	7	14	337

EMPLOYMENT (1000)

Concentration Ratio	Subsample				
	P1	P2	P3	P4	Total
0 ≤ CR ≤ 0.2	379	418	43	-	840
0.2 < CR ≤ 0.4	389	433	133	212	1167
0.4 < CR ≤ 0.6	791	827	39	73	1730
0.6 < CR ≤ 0.6	812	29	-	46	887
0.8 < CR ≤ 1.0	337	162	4	8	511
	2708	1869	219	339	5135

---

*Includes 45 NSF cases

Tables 3.4 through 3.7 compare the distribution of innovations with the distribution of employment with respect to concentration ratio for small and large firms in subsamples P1 and P2. In testing for a concentration ratio (CR) effect, the null hypothesis is that there is no effect and that innovation is directly proportional to employment.

II. Findings

1.a Within P1, the frequency of innovation by small firms in very diffuse industries ($0 < CR < 0.2$) is well below the average rate per employee for all small firms in P1, and the frequency of innovation in slightly and moderately concentrated industries ($0.2 < CR \leq 0.6$) is greatly in excess of the average rate per employee.

1.b Within P2, small firms in very diffuse industries ($0 \leq CR \leq 0.2$) and in moderately concentrated industries ($0.4 < CR \leq 0.6$) innovate less than the average rate per employee for all small firms in P2. Firms with concentration ratios in the interval $0.2 < CR \leq 0.4$ tend to innovate above the average rate per employee.

2.a Within P1, large firms tend to innovate above the average rate (per employee for all large firms in P1) with slight and moderate concentration ($0.2 < CR < 0.6$) and below the average rate in the upper range of $0.6 < CR < 1.0$.

Table 3.4

COMPARISON OF THE DISTRIBUTION OF INNOVATIONS WITH THE DISTRIBUTION OF EMPLOYEES WITH RESPECT TO CONCENTRATION RATIO FOR SMALL FIRMS IN PI

Concentration Ratio	Innovations		Employment (1000)	
	f	%	f	%
$0 \le CR \le 0.2$	17	14	421	52
$0.2 < CR \le 0.4$	41	34	153	19
$0.4 < CR \le 0.6$	56	46	161	20
$0.6 < CR \le 0.8$	7	6	78	10
$0.8 < CR \le 1.0$	0	0	3	0
	121		816	

$\chi^2 = 93$

DF* = 3

Sig. Level: 1%

---

*Degrees of freedom equals 3 as the result of combining the intervals $0.6 < CR \le 0.8$ and $0.8 < CR \le 1.0$ for the χ^2 test.

Table 3.5

COMPARISON OF THE DISTRIBUTION OF INNOVATIONS WITH THE DISTRIBUTION OF EMPLOYEES WITH RESPECT TO CONCENTRATION RATIO FOR SMALL FIRMS IN P2

Concentration Ratio	Innovations		Employment (1000)	
	f	%	f	%
$0 \le CR \le 0.2$	31	35	160	42
$0.2 < CR \le 0.4$	46	52	134	35
$0.4 < CR \le 0.6$	7	8	76	20
$0.6 < CR \le 0.8$	2	2	4	1
$0.8 < CR \le 1.0$	3	3	4	1
	89		378	

$\chi^2 = 20$
D.F.* = 3
Sig. Level: 1%

---

*The intervals $0.6 < CR \le 0.8$ and $0.8 < CR \le 1.0$ were combined for the χ^2 test.

Table 3.6

COMPARISON OF THE DISTRIBUTION OF INNOVATIONS WITH THE DISTRIBUTION OF EMPLOYEES WITH RESPECT TO CONCENTRATION RATIO FOR LARGE FIRMS IN P1

Concentration Ratio	Innovations		Employment (1000)	
	f	%	f	%
$0 \le CR \le 0.2$	21	10	379	14
$0.2 < CR \le 0.4$	74	36	389	14
$0.4 < CR \le 0.6$	82	40	791	29
$0.6 < CR \le 0.8$	29	14	812	30
$0.8 < CR \le 1.0$*	1	0	337	12
	207		2708	

$\chi^2 = 114$

DF* = 3

SL = 1%

---

*The intervals $0.6 < CR \le 0.8$ and $0.8 < CR \le 1.0$ were combined for the χ^2 test.

Table 3.7

COMPARISON OF THE DISTRIBUTION OF INNOVATIONS WITH THE DISTRIBUTION OF EMPLOYEES WITH RESPECT TO CONCENTRATION RATIO FOR LARGE FIRMS IN P2

Concentration Ratio	Innovations		Employment (1000)	
	f	%	f	%
$0 \leq CR \leq 0.2$	42	39	418	22
$0.2 < CR \leq 0.4$	43	39	433	23
$0.4 < CR \leq 0.6$	17	16	827	44
$0.6 < CR \leq 0.8$	4	4	29	2
$0.8 < CR \leq 1.0$*	3	3	162	9
	109		1869	

$\chi^2 = 47$
D.F.* = 3
Sig. Level: 1%

---

*The intervals $0.6 < CR \leq 0.8$ and $0.8 < CR \leq 1.0$ were combined for the χ^2 test.

2.b Within P2, the innovation performance of large firms is similar to that noted in P1 but shifted toward the lower concentration ratios. The frequency of innovation is above average at the low end ($0 \leq CR \leq 0.4$) and below average for moderate concentration ($0.4 < CR \leq 0.6$).

3. Small and large firms exhibit substantially the same distributions of innovations with respect to concentration ratio in both P1 and P2 (Table 3.8). The interval $0.2 < CR \leq 0.6$ in P1 and the interval $0 \leq CR \leq 0.4$ in P2 are the major producers of innovations.

4. The number of innovations per million employees in industries with growing employment differs significantly from that in industries with declining employment. For small firms the rates are respectively 145 and 187 innovations per million employees. The corresponding rates for large firms are 73 and 56 innovations per million employees. The average rate taken over all small firms is 162 innovations per million. For large firms the rate is 66 per million.

5. Small firms produce significantly more innovations than large firms per employee. See Tables 3.9 and 3.10. Overall, small firms produce 2.5 times as many innovations per employee as large firms.

6. The distributions of innovations by small and large firms were compared with respect to the following time variables measured from the year of market introduction:

T_{CRIT} - Year performance criteria established
T_{ENG} - Year preliminary design finalized
T_{PROTO} - Year prototype developed
T_{PROD} - Year of first production

Table 3.8

COMPARISON OF THE DISTRIBUTION OF INNOVATIONS WITH RESPECT TO CONCENTRATION RATIO AND FIRM SIZE

Concentration Ratio	INNOVATIONS P1 Firm Size		INNOVATIONS P2 Firm Size	
	Small	Large	Small	Large
$0 \leq CR \leq 0.2$	17	21	31	42
$0.2 < CR \leq 0.4$	41	74	46	43
$0.4 < CR \leq 0.6$	56	82	7	17
$0.6 < CR \leq 0.8$	7	29	2	4
$0.8 < CR \leq 1.0$	0	1	3	3
	121	207	89	109
	$X^2 = 7.0$ DF* = 3 SL : 10%		$X^2 = 4.3$ DF* = 3 SL : NS	

---

*Combined the intervals $0.6 < CR \leq 0.8$ and $0.8 < CR \leq 1.0$.

Table 3.9

COMPARISON OF THE FREQUENCY OF INNOVATION BETWEEN SMALL AND LARGE FIRMS IN INDUSTRIES FOR WHICH THE NUMBER OF ESTABLISHMENTS INCREASED AND EMPLOYMENT INCREASED (P1)

	Innovations	Industry Employment (1000)
Small Firms	121	816
Large Firms	207	2708

$\chi^2 = 35$
D.F. = 1
Sig. Level: 1%

Table 3.10

COMPARISON OF THE FREQUENCY OF INNOVATION BETWEEN SMALL AND LARGE FIRMS IN INDUSTRIES FOR WHICH THE NUMBER OF ESTABLISHMENTS INCREASED AND EMPLOYMENT DECREASED (P2)

	Innovations	Industry Employment (1000)
Small Firms	89	378
Large Firms	109	1869

$\chi^2 = 112$
D.F. = 1
Sig. Level: 1%

The distributions of these variables are given in Table 3.11. Analysis of these distributions indicates that small firms tend to bring their innovations to market sooner than large firms. The mean time from the establishment of performance criteria to market introduction is 2.22 years for small firms and 3.05 years for large firms.

Table 3.12 shows that, on average, small firms take less time to carry out each of the several activities on the path from the establishment of performance criteria to market introduction.

7. Table 3.13 shows a frequency distribution with respect to concentration ratio of innovations introduced by large firms. In the concentration ratio range $0 \leq CR \leq 0.4$, 20 percent of the innovations were acquired from outside the firm. In the interval $0.6 < CR \leq 1.0$, 34 percent were acquired from outside. This difference is significant at the 10 percent level and tends to support the hypothesis that a greater proportion of the innovations introduced by large firms in concentrated industries is acquired from outside the firm than is the case for large firms operating in less concentrated industries.

The corresponding hypothesis for small firms is not supported by the data. In the interval $0 \leq CR \leq 0.4$, 23 percent (8 of 35) of the innovations were acquired from outside small firms. In the interval $0.06 < CR \leq 1.0$, 17 percent (1 of 6) were acquired from outside.

Table 3.11

DISTRIBUTION OF INNOVATIONS WITH RESPECT TO TIME FOR ACTIVITIES LEADING TO THE INTRODUCTION OF INNOVATION

	T_{CRIT}		T_{ENG}		T_{PROTO}		T_{PROD}	
Year**	SM	LG	SM	LG	SM	LG	SM	LG
-5	6	42	3*	11*	5	15	-	-
-4	4	19	4*	14*	3*	5*	-	-
-3	7	26	3	17	1*	13*	-	-
-2	16	35	14	33	3	30	3	13
-1	21	30	22	40	35	53	10	22
0	-	-	13	15	13	32	49	95
+1	-	-	-	-	-	-	4	6
Mean Time	-2.22	-3.05	-1.53	-2.06	-1.35	-1.67	-0.18	-0.31
	X^2 = 12.6		X^2 = 7.34		X^2 = 12.8		X^2 = 1.80	
	DF = 4		DF = 4		DF = 4		DF = 3	
	SL: 5%		SL: NS		SL: 5%		SL: NS	

---

*Data in intervals combined for χ^2 test.

**High (Low) year in each column includes events reported in earlier (later) years.

Table 3.12

MEAN TIMES FOR ACTIVITIES BETWEEN ESTABLISHMENT OF PERFORMANCE CRITERIA AND MARKET INTRODUCTION

Mean Time To:	Small Firms	Large Firms
Engineer Product	0.69 years	0.99 years
Develop Prototypes	0.18	0.39
Establish Production	1.17	1.36
Sales Start Up	0.18	0.31
Mean Time from Establishment of Performance Criteria to Market Introduction	2.22 years	3.05 years

Table 3.13

DISTRIBUTIONS OF INNOVATIONS WITH RESPECT TO CONCENTRATION RATIO AND PARTITIONED BY SOURCE OF INNOVATION*

	Small Firms		Large Firms	
Concentration Ratio	Total Innovations	Innovations Acquired From Outside	Total Innovations	Innovations Acquired From Outside
$0 \leq CR \leq 0.2$	14	3	34	5
$0.2 < CR \leq 0.4$	21	5	65	15
$0.4 < CR \leq 0.6$	30	10	49	14
$0.6 < CR \leq 0.8$	5	1	25	9
$0.8 < CR \leq 1.0$	1	0	4	1
	71	19	177	44

---

*Includes 45 NSF cases

8. Table 3.14 shows the distributions of innovations for small firms with respect to a measure of industry capital intensity (capital stocks per employee) and a measure of industry growth (annual employment growth rate).

Table 3.15 shows the distribution of employees among small firms in industries generating innovations reported in the survey, with respect to industry capital stocks per employee and industry employment growth rate.

Tables 3.14 and 3.15 are the basis for testing the hypothesis that the frequency of small firm innovation is independent of industry capital intensity. Table 3.16 compares the distribution of innovations in small firms in industries for which total employment increased with the distribution of small firm employees in the same industries. Table 3.17 does the same for industries with decreasing total employment. The data indicate that the frequency of innovation by small firms is not affected by industry capital intensity.

Tables 3.18 and 3.19 show a different pattern for large firms. The frequency of innovation by large firms appears to be related to the capital intensiveness of its industry. Large firms in the more capital-intensive industries tend to be significantly less innovative than large firms in less capital-intensive industries.

Other Findings

9. Table 3.20 indicates that large firms receive more frequent public funding for innovation-related purposes than do small firms. It also shows that small and large firms apply public funds to the same purposes with substantially the same frequencies.

Table 3.14

DISTRIBUTION OF INNOVATIONS* FROM SMALL FIRMS WITH RESPECT TO INDUSTRY CAPITAL STOCK PER EMPLOYEE (S), AND EMPLOYEE GROWTH (G)

Employee Growth	Capital Stock Per Employee ($1000)			
	S ≤ 10	10 < S ≤ 15	15 < S ≤ 20	20 < S
G ≤ 0	5	52	37	9
0 < G	5	79	22	12

---

*Excludes 45 NSF cases.

Table 3.15

DISTRIBUTION OF EMPLOYEES (1000) OF SMALL FIRMS IN INDUSTRIES REPORTING INNOVATIONS WITH RESPECT TO INDUSTRY CAPITAL STOCK PER EMPLOYEE (S), AND EMPLOYEE GROWTH* (G)

Employee Growth	Capital Stock Per Employee ($1000)			
	$S \leq 10$	$10 < S \leq 15$	$15 < S \leq 20$	$20 < S$
$G \leq 0$	44	204	152	36
$0 < G$	59	317	113	47

---

*Excludes 45 NSF cases.

Table 3.16

COMPARISON IN INDUSTRIES WITH INCREASING EMPLOYMENT OF THE FREQUENCY OF INNOVATION BY SMALL FIRMS WITH THE DISTRIBUTION OF EMPLOYEES WITH RESPECT TO CAPITAL STOCK PER EMPLOYEE*

S: Capital Stock per Employee ($1,000)	Distribution of Innovations	Distribution of Employees (1,000)
$S \leq 15$	84	376
$15 < S \leq 20$	22	113
$20 < S$	12	47
	118	536

$\chi^2 = 0.61$
DF = 2
SL: NS

---

*Excludes 45 NSF cases.

Table 3.17

COMPARISON IN INDUSTRIES WITH DECLINING EMPLOYMENT OF THE FREQUENCY OF INNOVATION BY SMALL FIRMS WITH THE DISTRIBUTION OF EMPLOYEES WITH RESPECT TO CAPITAL STOCK PER EMPLOYEE*

S: Capital Stock per Employee ($1,000)	Distribution of Innovations	Distribution of Employees (1,000)
$S \leq 10$	5	44
$10 < S \leq 15$	52	204
$15 < S \leq 20$	37	152
$20 < S$	9	36
	103	436

$x^2 = 3.16$

DF = 3

SL: NS

---

*Excludes 45 NSF cases.

Table 3.18

COMPARISON IN INDUSTRIES WITH INCREASING EMPLOYMENT OF THE FREQUENCY OF INNOVATION BY LARGE FIRMS WITH THE DISTRIBUTION OF EMPLOYEES WITH RESPECT TO CAPITAL STOCK PER EMPLOYEE*

S: Capital Stock per Employee ($1,000)	Distribution of Innovations	Distribution of Employees (1,000)
$S \leq 10$	8	141
$10 < S \leq 15$	112	839
$15 < S \leq 20$	30	834
$20 < S$	36	790
	186	2,604

$X^2 = 68$

DF = 3

SL: 1%

---

*Excludes 45 NSF cases.

Table 3.19

COMPARISON IN INDUSTRIES WITH DECLINING EMPLOYMENT OF THE FREQUENCY OF INNOVATION BY LARGE FIRMS WITH THE DISTRIBUTION OF EMPLOYEES WITH RESPECT TO CAPITAL STOCK PER EMPLOYEE*

S: Capital Stock per Employee ($1,000)	Distribution of Innovations	Distribution of Employees (1,000)
$S \leq 15$	56	778
$15 < S \leq 20$	45	361
$20 < S$	13	548
	114	1,687

$\chi^2 = 33$

DF = 2

S: 1%

---

*Excludes 45 NSF cases.

Table 3.20

USE OF PUBLIC FUNDS

(DF = 1 for all cases)

	Was technology developed by R&D?		Were public funds used?	
	S	L	S	L
No	4	8	62	145
Yes	66	168	4	30
x^2	0.003		3.98	
SL	NS		5%	

APPLICATION OF PUBLIC FUNDING

	Basic Research		Applied Research		Development		Engineering	
	S	L	S	L	S	L	S	L
No	2	16	2	7	1	5	2	13
Yes	2	13	2	22	3	25	2	17
x^2	0.04		0.24		0.08		0.08	
SL	NS		NS		NS		NS	

	Production		Distribution and Marketing		Other	
	S	L	S	L	S	L
No	3	19	4	26	4	27
Yes	1	10	0	3	0	2
x^2	0.04		0.06		0.09	
SL	NS		NS		NS	

10. Table 3.21 indicates that most small firms reporting innovations were closely held (78 percent) at the time the innovation was introduced and that 17 percent of the small firms changed their form of ownership following introduction of an innovation.

11. Table 3.22 shows that at the time of market introduction, an innovation is more likely to be a firm's only product if the firm is small than if a firm is large. It also shows that the innovations of small firms are more likely to initiate a broad line of new products. Table 3.23 shows that the percentage of small firm innovations introduced into consumer markets and government markets is greater than that of large firms and that a greater percentage of large firm innovations are for internal users.

12. Table 3.24 indicates that a greater percentage of small firms tend to also sell their product abroad after introduction.

Table 3.21

BUSINESS OWNERSHIP

Has ownership form changed?

	S	L
No	53	133
Yes	11	4
x^2	10.88	
SL	1%	
DF	1	

Previous form of ownership

	S	L
Closely Held	53	24
Publicly Held	15	146
x^2	87.51	
SL	1%	
DF	1	

Table 3.22

PRODUCT LINE

(DF = 1 for all cases)

	Was Innovation Only Product		Is Innovation Now Only Product		Was Innovation First in Broad Line		Did Product Enter a New Market	
	S	L	S	L	S	L	S	L
No	62	175	62	135	41	130	38	117
Yes	9	2	4	2	26	46	29	57
x^2	13.33		1.88		3.15		2.12	
SL	1%		NS		10%		NS	

Table 3.23

PRODUCT MARKET CLASS

(DF = 1 for all cases)

	PRODUCERS		DISTRIBUTORS		CONSUMERS		GOVERNMENT		INTERNAL	
	S	L	S	L	S	L	S	L	S	L
NO	26	56	56	114	26	114	32	114	65	152
YES	41	120	6	23	41	62	35	62	2	24
X^2	0.77		1.21		12.36		5.16		4.70	
SL	NS		NS		1%		5%		5%	

Table 3.24

INTERNATIONAL MARKETING

Was product first sold abroad?

	S	L
No	60	122
Yes	5	11
X^2	0.02	
SL	NS	
DF	1	

Was product sold abroad after U.S. introduction?

	S	L
No	6	28
Yes	58	106
X^2	3.27	
SL	10%	
DF	1	

THE ROLE OF PATENTS IN THE COMMERCIALIZATION OF NEW TECHNOLOGY FOR SMALL INNOVATIVE COMPANIES

Final Report of a Survey Conducted
by Research & Planning, Inc. for the
Small Business Administration

Judith H. Obermayer, Ph.D.
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August, 1981

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Judith Obermayer, Ph.D.
Principal Investigator

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EXECUTIVE SUMMARY

Introduction

In the past, the protection of the patent system has provided a major incentive for the development and commercialization of new technologies. The rate of investment required to bring new products to commercial utilization and the nature and speed of technological progress have changed in the last several decades. The increasing cost of using the patent system, the trend toward litigation and infringement of patent rights and the attitude of the courts toward patents have decreased the contribution of the patent system to technological innovation. Small companies, which have been a critical source of important new technology, have been particularly affected by the problems of the United States Patent System.

The survey explored in detail, from the point of view of small high technology firms, the interaction between businesses and the patent system. It examined how current patent policy and perceptions of policy affect management decision making, and how government procurement policies that relate to patent rights influenced the possible commercialization of new technology. It considersed the usefulness of the patent system to these companies as well as the problems faced by them in relying on patents for market protection, including the cost of threatened litigation. The attitudes and experiences of large firms are included as a comparison and to reveal any disparities in the ways in which the two groups perceive and use patents. Also examined is the extent to which current policies tend to encourage the use of trade secrets and proprietary know-how, as opposed to patents, and thereby keep new technical knowledge out of the public domain. The impact of patent maintenance fees on corporate strategy is also explored. An analysis of the present situation is followed by the results of an opinion survey on a number of recommendations for changing patent policy.

General Conclusions

In the early days of the patent system, it was customary for the individual inventor to apply directly to the Patent Office for a patent. The process required a minimum of time and expense. Over the years, as the system grew and the use of technology broadened, the patent system grew more complex and expensive to use. It is rare today for an inventor to write a patent application without at least consulting a patent attorney. The process of conducting a patent search for prior relevant technology is expensive, and frequently the strength of the patent depends on the extent of the search. Gradually there has been a movement toward patent system use being limited to those more able to afford it.

Coupled with this shift in who uses the patent system has been the influence of public opinion. The general public is uneasy about patents and seems to look on them as a giveaway to business. There is little understanding or recognition of the importance of patent protection to the nurturing and development of new technology and hence to the economic growth of the country. The ultimate manifestation of this public uneasiness is the attitude of the courts toward patents. Most patent disputes that go to trial are complicated and require a careful evaluation of a technical area. As in most legal proceedings, the answers are not black and white but various shades of grey. The courts, when in doubt, tend to rule against the patent system and declare the patent invalid. The belief is that such a decision will open up the development of the technology to competition, and that is preferred. Since only a few patents are challenged in the courts, the effect on competition is relatively small.

What is not clearly perceived is the chilling effect that these decisions and the attitude they represent have on the use of the patent system as a whole, and on innovation in particular. It is recognized that only valuable patents are cause for a major legal dispute; when people believe that any truly profitable patent is likely to be declared invalid (after a lengthy and expensive court battle), they look for other methods of protecting their technology. If the technological development carries a high risk of failure without an assured protected market position, it may never be explored at all. At the same time, a dependence on other methods to protect technology makes whatever advances have been made in scientific knowledge inaccessable to the public. Technological development is a sequential process with each step building on a number of previous ones. Without the free exchange of knowledge, progress is drastically impeded.

It has been demonstrated repeatedly that the small business sector is a major producer of innovation, especially when radically new, high-risk technology is involved. However, these companies are rarely in a position to completely fund the development and market introduction of their technology by themselves. In order to attract the necessary capital from outside investors, small companies must demonstrate that a protected market niche exists that assures an adequate return on capital invested. Traditionally an important source of that protection has been the patent system. However, a patent system limited more and more to large companies and that affords protection perceived as uncertain at best, leaves the small company in an increasingly difficult position. Substantial costs lead them to seek alternatives to patents such as trade secrets, which in turn reduces their protection in the marketplace, making outside capital investment more difficult to obtain.

This chain of events has clearly been accelerated by the introduction of maintenance fees into the patent system, further weakening the contribution of the patent system to the economic growth and development of the United States. The danger signals and trends are all present in the details of this study.

Perhaps the time has come to reexamine the basis for the existance of a patent system. Do we need a patent system at all? If we do, what should be its functions and goals? How should it be structured to effectively and reliably fulfill those goals? A broad public debate on these issues is a necessary first step. In the last few years, the concern over the decreased rate of innovation in the United States has led to a significant increase in awareness by the Congress of the patent system, its role and its weaknesses. There is still little public understanding of the economic reasons for the existence of a patent system. The result has been a decline in support for the patent system which has gradually become less effective at achieving its original purpose. A patent system that operates ineffectively and unreliably is worse than no system at all. A public consensus must be reached on the value of a patent system for the United States and the function it should serve. Then we can go forward with the support of public opinion and the necessary financial resources to build a system that fulfills its purpose.

Population Surveyed

Three separate sets of questionnaires were mailed. Each of the first two mailings were sent to over 400 small high technology companies: the first was aimed at small R&D oriented companies and the second went to companies more oriented toward manufacturing. The third mailing went to about 50 large corporations.

Extent of Patent Use

Although two-thirds of the small companies hold patents, the vast majority hold fewer than 15. In addition, many of the small companies only use a small percentage of their patents. By contrast, the large companies appear to use a greater proportion of their patents. In looking at the use of patents by field of technology, it is clear that small electronics and computer oriented companies use patents less than any other technical fields.

Factors in Promotion of Technology

Companies were asked to rate the importance of the following factors in the decision to promote new technology: patent protection, proprietary information and know-how, market potential, amount of investment required, and time to reach the marketplace. There was marked unanimity among large and small companies on these ratings. Market potential and amount of investment were far and away most often the first and second factor in order of importance. Patent protection was rated only as a third, fourth or fifth factor.

Relationship Between Type of Market and Type of Protection Utilized

The large company respondents use both patents and proprietary technology protection to a greater extent than the small ones. As might be expected, patents are used more for products in high growth and new markets than in older, more stable markets. It is also true that the majority of products that are radically new or fundamentally different from available products use patent protection, as do those products that require a substantial or outstanding level of R&D to develop.

Barriers to Use of Patent Systems

In order to explore barriers to the use of the patent system, companies were asked to identify factors that play a role in the decision not to apply for a patent. The primary reason for not applying for possible patents for all sizes of companies was dependency on trade secrets and proprietary technology. For small companies, matters related to the costs of obtaining the patent in the first instance, or possibly defending it, were important influences. Also identified was the belief that patents were not sufficiently reliable and could be ruled invalid too easily.

Alternate Modes of Protection

The chief alternative to the use of patents is to rely on the protection of proprietary know-how and trade secrets. Over 80% of the small companies and almost all of the large companies use these alternate modes of protection. However, the ratings of the usefulness of these methods show that small companies find them more valuable. This may be a reflection of the extent to which small companies are involved in rapidly changing technical fields where patents quickly become obsolete or it may be a reflection of their lack of faith in the patent system.

Time and Costs of New Product Introductions

Several questions explored the length of time and amount of capital needed for the development and market introduction of new and improved products. The smaller manufacturing oriented companies are the fastest to get new or improved products into the marketplace. They are followed by the smallest, more R&D oriented companies. In general, it takes small companies less than 12 months to bring a product improvement or modification to the marketplace, and less than two years for a new product. By contrast, the large companies indicate that over a year is required for most product modifications and over two years for new product introductions. For the majority of companies, significant amounts of capital must be invested to make such an introduction possible.

The obvious difficulty faced by the small companies is the need to obtain outside funding when the costs are too great for development and marketing to be financed from current reserves and income. It is not surprising that the smallest companies are most dependent on outside sources of capital.

Role of Patents in Obtaining Outside Funding

Several questions were asked to determine the extent to which patents play a role in the decision to develop new technology. As was described earlier, patent protection is not the main consideration when business strategy is formulated. However, when significant amounts of capital need to be invested, most companies view patents as a vitally important or at least a significant factor in the ability to attract outside funding. This seems to be particularly true for the very small companies who are not yet in a manufacturing mode. Hence, the existence of patent protection is frequently a vital link in connecting technology with the funds necessary to achieve successful commercialization.

Reliability of Patents and Related Costs

There has been general concern that small companies with limited financial resources may be at a distinct disadvantage in defending themselves in a conflict involving patented technology. While the vast majority of companies estimate patent related expenses as less than two percent of overall expenses, several, including two large companies, estimate patent related expenses in excess of ten percent of all costs. The costs associated with patenting new technology are balanced against the degree of protection it is likely to provide. Companies carefully weigh the likelihood of having to defend the patent, the probability that the patent may be ruled invalid, and the ease with which another company can use the information in the patent and invent around it.

About a third of the small companies and all of the large ones have been in a dispute over patented technology. In general, both the total **time for resolution and the cost of resolving conflicts were significantly greater when large companies were involved.** Even in our relatively small sample, five large companies cited cases that went to trial and three went to appeals. In those cases where companies felt that the conflict was not resolved in a fair manner, the main reasons given related to high cost factors.

Relating to Contract R&D for the Government

Until the passage of PL 96-517 in December, 1980, there was no uniform patent rights policy for companies that performed contract research and development for the government. Each agency had its own rules. The congress in PL 96-517 has mandated that small businesses and universities (with some restrictions) are to receive title to patents resulting from government funding. **A significant number of companies indicated that past government policy inhibited or prevented the application of their most advanced private technology to government sponsored work.** Thus this new legislation should contribute important technology for national objectives.

Maintenance Fees

PL 96-517 which amended the patent and trademark laws, includes the introduction of maintenance fees into the U.S. system for the first time. Many European countries already have such fees. Under the new U.S. law, maintenance fees must paid 3 1/2 years, 7 1/2 years and 11 1/2 years after issue to keep a patent in effect. Without payment, the patented technology goes into the public domain. It is unclear what the level of these fees will be, but the legislation also requires a gradual increase in maintenance fees until they pay for at least 25% of the cost of running the patent office. Hence, the eventual fees will be substantial.

In our survey, companies were asked to evaluate the consequences of a cost for maintaining a patent for the full seventeen years from $500 to $3000. At each cost level they were asked what percent of patents they would maintain and whether there would be any significant impact on their business. Our survey findings indicate that by the time total maintenance fees reach the $2000 level, most companies of all sizes would maintain less than 60% of current patents. **When the fees per patent reach $3000, 60% of the small companies and 52% of the large companies who responded indicated that they would maintain less than 30% of current patents.** The percent of companies that felt maintenance fees would have an impact on their business ranged from 11% at fees of $500 to 39% at fees of $3000. **Over 30% of small companies and over 20% of large companies indicated that the imposition of maintenance fees would make them less likely to apply for a patent in the future.**

Possible Patent Law and Policy Changes

At the time this study was proposed, a large number of possible changes in patent policy were being considered. Many of the most important changes were passed at the end of 1980 and are part of PL 96-517. Although the implementing regulations are not yet in effect, the new law includes provisions for a patent reexamination procedure, for small businesses and universities to receive patent rights for inventions developed under government sponsored research, and for the institution of maintenance fees.

A number of other changes in the way the patent system operates have been suggested. Respondents were asked for their opinions on a number of them. The overwhelming majority favored the extension of patent life in cases where government regulations delay market introduction, and the establishment of a single Court of Patent Appeals. About half of the small companies and most of the large companies also favor an independent Patent and Trademark Office.

I. INTRODUCTION

The history of the patent system goes back to the U.S. Constitution, which empowers Congress

> To promote the progress of science and useful arts, by securing for limited times to authors and inventors, the exclusive right to their respective writings and discoveries.

The framers of the Constitution recognized the need to encourage and reward inventors by granting them the right to the initial profits from their own inventions. The lack of such guarantees provides a severe discentive for the large expenditures in time and capital so often required for successful innovation. The social value of patents is enhanced by their time limitations and status as public documents, which provide a process for the eventual diffusion of new technology into the public domain where it can lead to additional technological development.

Over the years, as the structures of our economy, technology and legal system have evolved, the role of patents has undergone a gradual but extensive change. Among the factors that have contributed to this change are: increases in time and difficulties of obtaining a patent, increases in the cost and time of defending patents, frequency with which patents are declared invalid, and attitudes and policies of the government towards its contractors and their patent rights.

Without the protection of a reliable patent system, many of the earliest innovations in new fields of technology from small companies would never have progressed beyond the invention stage.

It is incumbent upon us to examine any current inequities in the operation of the patent system and disincentives in the government procurement policies to look for ways to restore a more even-handed system and remove barriers to greatly needed innovation. It is easy to document isolated instances of difficulties faced by small businesses in using the patent system with government procurement policies. This study has been done to look at many aspects of these problems and to assess their seriousness as an inhibitor of innovation for a larger sample of companies.

The project explored in detail, from the point of view of small, high technology firms, the interaction between businesses and the patent system, how current patent policy and perceptions of policy affect management decision making, and how government procurement policies related to patent rights influence the possible commercialization of new technology. Of concern was the usefulness of the patent system to these companies as well as the problems faced by them in relying on patents for market protection, including the cost of threatened litigation. We also compared the results with the attitudes and experiences of large firms to document the extent of any disparity in the ways the two groups perceive and use patents. We examined the extent to which the current policies tend to encourage the use of trade secrets and proprietary know-how, as opposed to patents, thereby keeping new, technical knowledge out of the public domain. The impact of patent maintenance fees on corporate strategy was also explored. An analysis of the present situation is followed by the results of an opinion survey of a number of recommendations for changing patent policy.

II. METHODOLOGY

A. Questionnaire Construction

The questionnaires used to try to evaluate the role of the patent system consisted of six sections. The first section asked general background information about the nature and size of the business. The second section explored the extent to which the company uses patents, how important patents are, what are the barriers to using the patent system, and the value of alternate modes of protection. There were also a series of questions to identify the characteristics of two of the most valuable company products or processes. These questions were aimed at seeing if there is any link between certain types of products and markets and the relative importance of patent protection.

The third section contained questions on the magnitude of patent related expenses. The frequency of conflicts over patented technology, the cost of any disputes, the time until resolution, and the size of the other organization involved in the dispute were considered.

The fourth section explored the companies involvement (if any) in contract R&D for the government and the effect of government contract conditions on company strategy and product commercialization.

The last two sections related directly to new and proposed patent legislation. The fifth section explored the likely impact of various levels of patent maintenance fees on company strategy and level of reliance on patents. The sixth section was an opinion poll on various legislative proposals related to the operation of the patent system.

To the extent possible, questions were phrased so as to be equally applicable to small and large organizations. The only differences were in questions that measured the size of the organization or level of expenses for various activities. A copy of the actual small company questionnaire is included as Appendix A.

B. Company Selection Process

The initial mailing of over 400 questionnaires went to members of the American Association of Small Research companies and to companies that received grants under the NSF's Small Business Innovation Research Program. These companies are highly technically oriented and many of them have performed contract research for the government. The name of the principal investigator was known to many of them, which tends to improve the response rate on a survey.

In order to balance the R&D emphasis of this initial mailing, a second mailing was made to a more manufacturing oriented group of companies. The companies were selected by using listings by SIC code. The four major SIC code groups used were Group 35, machinery, except electrical; Group 36, electrical and electronic machinery, equipment and supplies; Group 38, measuring analyzing and controlling instruments, and photographic, medical, and optical goods; and Group 28, chemicals and allied products. A firm's industrial group is classified as "manufacturer" when its two-digit code falls between 20 and 39, and thus our choices insured that none of our companies were simply distributors.

Using the four major product groups as a base, ten specific classifications were extrapolated.

1. Electronic Computing Equipment SIC 3573
2. Electronic Assemblies SIC 3679
3. Electronic Components and Accessories SIC 3671-3679
4. Instruments--Laboratory, Scientific, and Research SIC 3671-3679
5. Instruments--Measuring and Controlling SIC 3822-3825
6. Instruments--Optical and Opthammic Goods SIC 3832, 3851
7. Instruments and Supplies--Surgical, Medical and Dental SIC 3841-3843
8. Medical Apparatus--Electronic SIC 3693
9. Industrial Inorganic Chemicals SIC 2813
10. Plastics, Polymers, and Materials SIC 3823

Approximately 40 companies with between 0 and 200 employees were randomly drawn from each of the ten classifications; hence the total mailing figure of 400 companies. An effort was made to avoid any geographical biases within the sample. All questionnaires were sent with a letter personally addressed to a corporate officer and hand signed.

In order to compare the attitudes and experiences of small companies with those of large firms it was necessary to also survey a small group of large corporations. Questionnaires were sent to a senior management person or a senior member of the corporate patent staff. Personal contacts were used whenever possible, and this seemed to markedly improve the response rate. The cover letter included the request that in diversified firms, in order to narrow the field of technology, the response should refer to a single division or other integral business unit, not the whole company. Since, in most cases, the questionnaire was filled out by a corporate patent attorney, there may be some natural biases in the responses in favor of the importance of patents.

C. Rates of Response

Mailing	No.of Responses	Percent of Responses
1st Mailing	105	25%
2nd Mailing	49	12%
Large Companies	23	50%

III. SMALL COMPANY PROFILES

The first mailing respondents were primarily very small, fairly young companies, somewhat oriented toward government contracts. A significant proportion of these companies actually do over 80 percent of their business with the government. On the other hand, the second mailing, which was aimed at more manufacturing oriented companies, produced respondents that were a little bit larger, older and less dependent on government contracts. The first group had significantly more involvement in research and development and less emphasis on production than the second group. The first mailing respondents were more heavily oriented toward electronic, computer and physics related technology. The data from the two mailings will be broken down in the later sections if the differences between them seem significant.

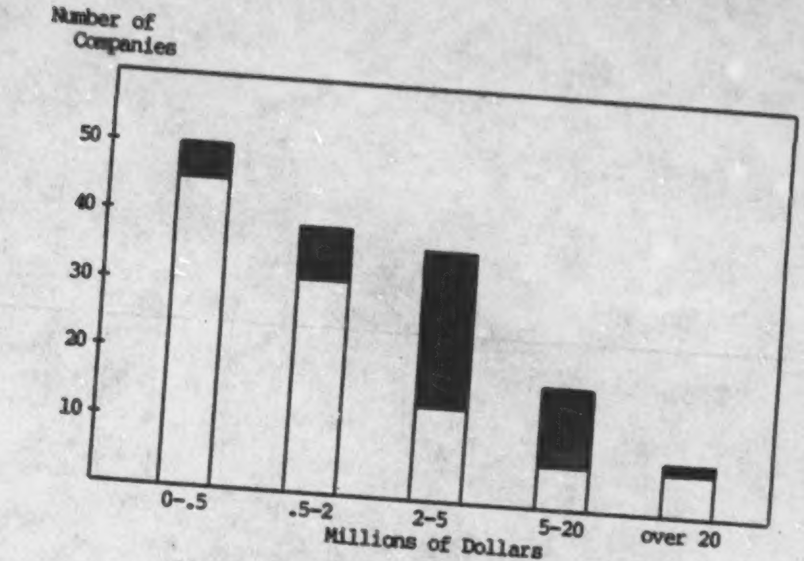


Figure 3.1 Size of Companies by Sales Volume

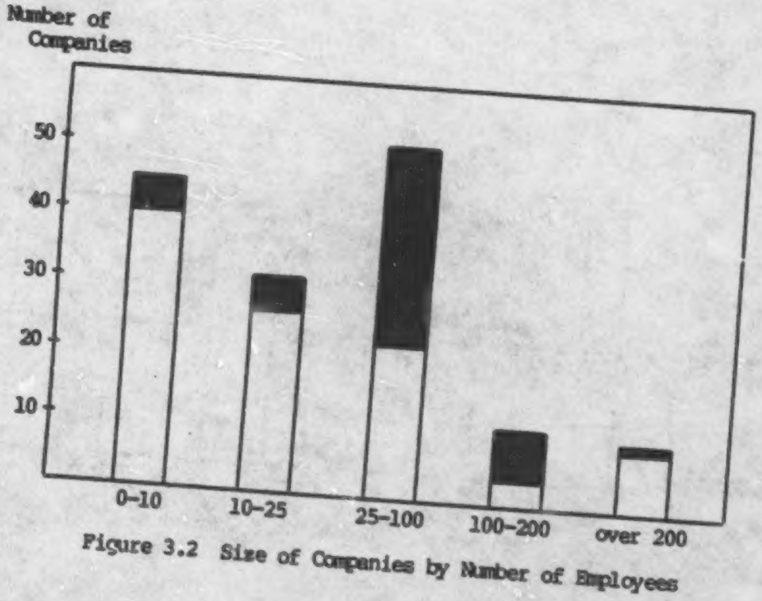


Figure 3.2 Size of Companies by Number of Employees

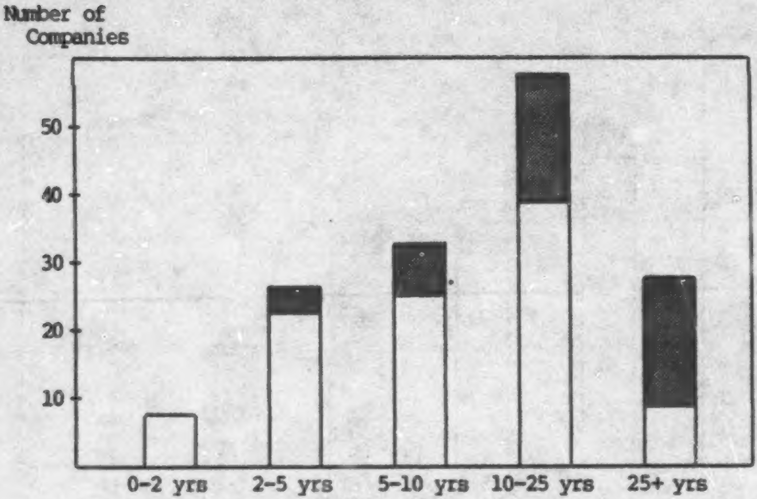


Figure 3.3 Age of Companies

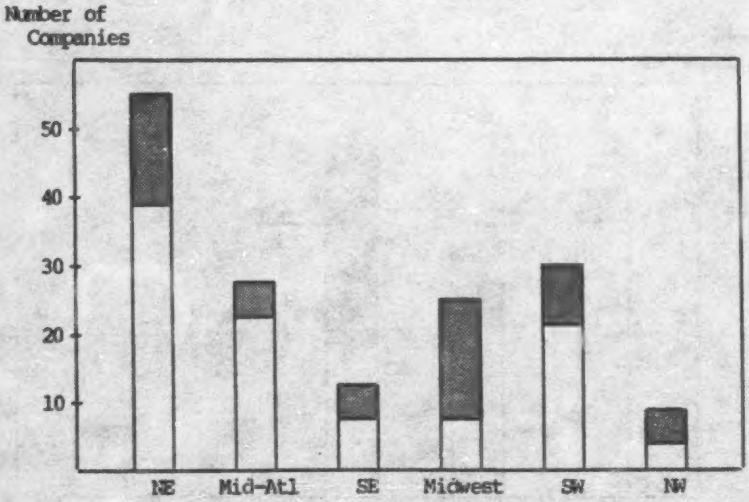


Figure 3.4 Location of Companies

Level of Different Company Activities
(as percent of company expenses)

Research & Development

	0-24%		25-49%		50-74%		75-100%		No level indicated	
1st Mailing	40	38%	11	10%	11	10%	22	21%	21	20%
2nd Mailing	36	73%	1	2%	1	2%	0	0%	11	23%
Total Small	76	49%	12	7%	12	7%	22	14%	32	21%

Production

1st Mailing	12	11%	13	12%	15	14%	5	5%	60	57%
2nd Mailing	4	8%	10	20%	15	31%	6	12%	14	29%
Total Small	16	10%	23	15%	30	19%	11	7%	74	48%

Sales

1st Mailing	45	43%	11	10%	1	1%	0	0%	48	44%
2nd Mailing	29	59%	7	15%	1	2%	0	0%	11	23%
Total Small	74	48%	18	12%	2	1%	0	0%	60	39%

Service

1st Mailing	24	23%	11	10%	3	3%	10	10%	57	54%
2nd Mailing	21	43%	1	2%	0	0%	1	2%	26	53%
Total Small	45	29%	12	7%	3	2%	11	7%	83	54%

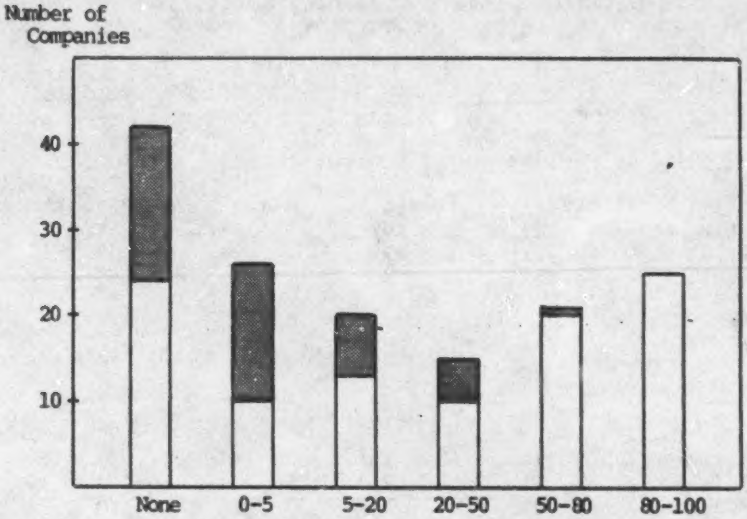


Figure 3.5 Percent of Sales in Connection with Government Contracts and Subcontracts

Primary Field of Technology	1st Mailing		2nd Mailing		Total Small		Large	
Chemistry	16	15%	14	29%	30	19%	10	43%
Electronics & Computers	15	14%	4	8%	19	12%	0	0%
Physics	22	21%	3	6%	25	16%	3	13%
Medical & Biological	3	3%	8	16%	11	7%	1	4%
Engineering & Design	27	26%	10	20%	37	24%	5	22%
Unknown	22	21%	10	20%	32	21%	4	17%

Although the large companies received questionnaires were spread across the fields of technology, those that responded are weighted heavily toward chemical technology and away from electronic technology. Hence, in areas which vary by field of technology, this sample is not the best.

IV. USEFULNESS OF THE PATENT SYSTEM VS. ALTERNATIVE MODES OF PROTECTION

A. Extent of Patent Use and Its Value

The second mailing, sent to the more manufacturing oriented companies, produced more involvement with the use of patents by the respondents than the first mailing. This may simply be an indication of the bias of those who actually filled out the questionnaire and returned it. It is also evident that most small companies do not hold a large number of patents. Although two-thirds of the small companies hold patents, the vast majority hold fewer than 15. In addition, many of the small companies only use a small percentage of their patents. By contrast the large companies seem to use a greater proportion of their patents. In looking at the use of patents by field of technology, it is clear that small electronics and computer oriented companies use patents less than any other technical fields.

Has your company ever applied for a patent?
(All of the large companies use patents)

	Yes		No	
1st Mailing	68	66%	35	34%
2nd Mailing	34	71%	14	29%
Total Small	102	68%	49	32%
Primary Field of Technology				
Chemistry	16	64%	9	36%
Electronics & Computers	9	43%	12	57%
Physics	19	73%	7	27%
Medical & Biological	6	86%	1	14%
Engineering & Design	27	84%	5	16%
Unknown	25	63%	15	37%

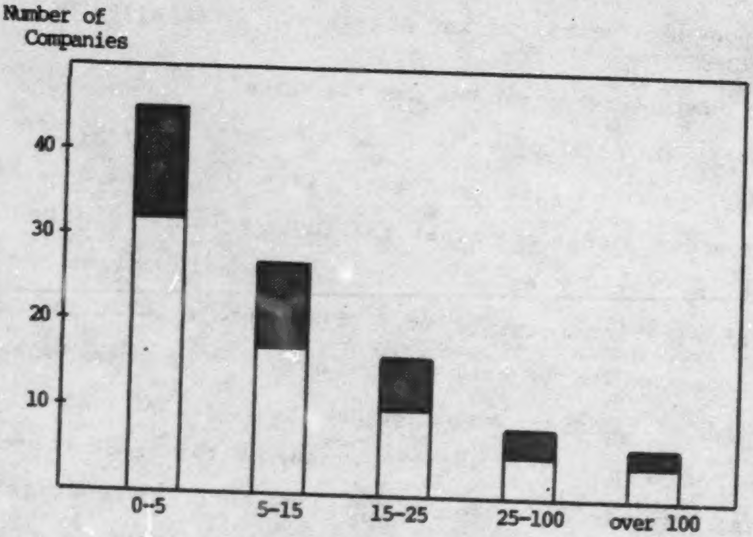


Figure 4.1 Number of Patents Held
Small Companies

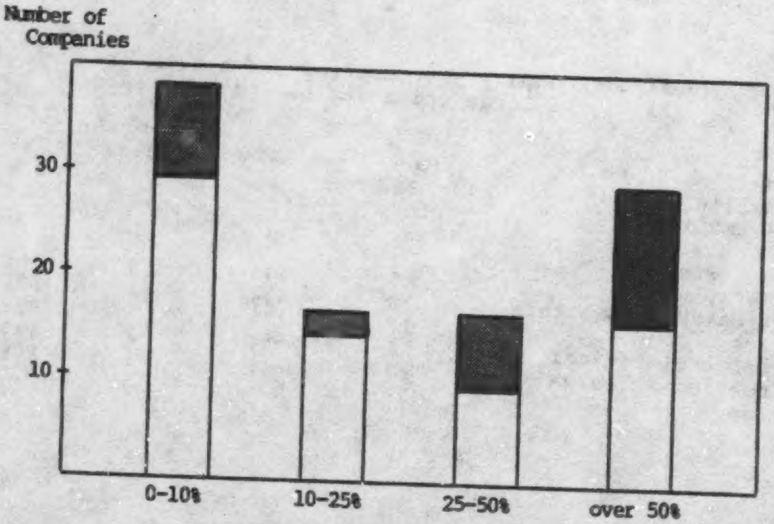


Figure 4.2a Percent of Patents Company is Using
Small Companies

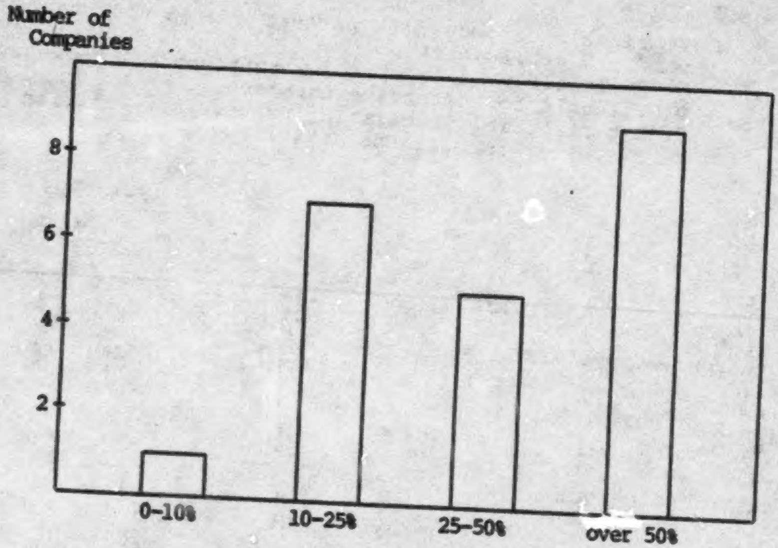


Figure 4.2b Percent of Patents Company is Using Large Companies

How valuable do you think patents are in your company? (check all applicable)
A. Of little value compared with technical know-how
B. Valuable for defensive purposes
C. Important in establishing proprietary position
D. Essential to business activities

	A		B		C		D	
Small	43	28%	33	21%	53	34%	29	19%
Large	4	17%	16	70%	18	78%	6	26%
Chemistry								
Small	4	13%	5	17%	10	33%	8	27%
Large	1	10%	8	80%	7	70%	5	50%
Electronics & Computers								
Small	3	16%	4	21%	6	32%	4	21%
Large	0	0%	0	0%	0	0%	0	0%
Physics								
Small	11	44%	6	24%	8	32%	3	12%
Large	1	33%	2	67%	3	100%	0	0%
Medical & Biological								
Small	2	19%	1	9%	3	27%	2	19%
Large	1	100%	0	0%	0	0%	0	0%
Engineering & Design								
Small	11	30%	6	16%	14	35%	5	14%
Large	1	20%	5	100%	5	100%	0	0%
Unknown								
Small	12	38%	11	34%	12	38%	7	22%
Large	0	0%	1	25%	3	75%	1	25%

Due to the small sample size and the technology distribution of the respondents, only the chemistry category yielded a sample sufficient to allow confidence that the results reflect the views of large organizations in that industry. It is clear that large chemically oriented companies believe that patents are an extremely important part of their business assets. Although no replies were received from large electronics and computer firms, a number of them are known for extensive use of patents. Their strategies, however, vary greatly, and range from using patents as a bargaining tool for extensive cross licensing agreements to vigorously defending their patents against any infringers.

To what extent do you rely on patents to protect your products?

	Always		Frequently		Seldom		Never/Does Not Apply	
Small	12	11%	35	33%	37	35%	23	22%
Large	1	4%	17	74%	4	17%	1	4%

B. Factors in Promotion of Technology

Companies were asked to rate the importance of the following factors in the decision to promote new technology: patent protection, proprietary information and know-how, market potential, amount of investment required, and time to reach the marketplace. There was marked unanimity between both large and small companies on the rating of factors in the decision to promote new technology. **Market potential and amount of investment were far and away the most common choices for the first and second factors.** Patent protection was only a third, fourth or fifth rated item.

Rate the importance of the following factors in the decision to promote new technology (#1 most important):

	1	2	3	4	5
Patent Protection					
Small	9	9	15	22	41
Large	0	4	5	10	2
Proprietary Information - Know How					
Small	16	16	19	28	11
Large	0	4	6	5	6
Market Potential					
Small	72	14	10	1	2
Large	20	1	0	0	0
Amount of Investment Required					
Small	8	46	26	11	5
Large	2	12	1	5	1
Time Required to Reach Marketplace					
Small	3	12	25	24	26
Large	0	1	9	1	10

C. Relationship Between Type of Market and Type of Protection Utilized

Companies were asked to characterize the nature of two specific products important to their company, and to include the types of protection employed. As can be seen from the cross tabulations that follow, the large company respondents use both patents and proprietary technology protection to a greater extent than the small ones. As might be expected, patents are used more for products in high growth and new markets than in older, more stable markets. It is also true that the majority of products that are radically new or fundamentally different from available products use patent protection, as do those products that require a substantial or outstanding level of R&D to develop. Although the mailings are not broken down, in most cases the values from the second mailing fall between the first mailing values and the large company values. Not all characteristics were filled in for all products and frequently more than one descriptive term was checked so percents do not add up to 100. One set of cross tabulations yielded the following (percentages refer to percent of products described):

	Type of Protection Utilized (may be more than one)		
Type of Market	Patents	Proprietary Technology	Brand Name No Legal Protection
Stable	33%	42%	27%
Growth	34%	53%	19%
New	45%	46%	11%

Figure 4.3a Percent of Products for Type of Protection in Different Types of Markets Small Company Products

	Type of Protection Utilized		
Type of Market	Patents	Proprietary Technology	Brand Name No Legal Protection
Stable	42%	42%	25%
Growth	71%	59%	12%
New	75%	63%	13%

Figure 4.3b Percent of Products for Type of Protection in Different Types of Markets
Large Company Products

	Type of Protection Utilized		
Type of Market	Patents	Proprietary Technology	Brand Name No Legal Protection
Stable	35%	42%	27%
Growth	39%	54%	18%
New	47%	47%	11%

Figure 4.3c Percent of Products for Type of Protection in Different Types of Markets
ALL PRODUCTS

	Type of Protection Utilized		
Type of Product	Patents	Proprietary Technology	Brand Name No Legal Protection
Same as other products available	0%	50%	20%
Slightly improved version of products available	17%	38%	31%
Substantially improved version of products available	41%	46%	22%
Radically new and/or fundamentally different from products available	55%	47%	13%

Figure 4.3d Percent of Products for Type of Protection by Type of Product
All Products

Level of R&D Required	Type of Protection Utilized Patents	Proprietary Technology	Brand Name No Legal Protection
Little	14%	29%	14%
Some	36%	36%	21%
Substantial	38%	52%	21%
Outstanding	49%	54%	12%

Figure 4.3e Percent of Products for Type of Protection by Level of R&D Required

One large company president summed up most of the views expressed when he described his company's view:

> Patent values and influence are highly variable from project to project. For entirely new products where we may be entering a field new to us where others have entrenched engineering, manufacturing, and market strengths, a patent position may be of critical significance to the decision to make the investment and enter that field. In this category, we likely view patents similar to small businesses or new ventures. The patent is viewed as a shield to protect the business during its start-up phase when it is most vulnerable. In areas where we feel that we are industry pace setters because of heavy R&D investments, patents are viewed as supportive of this investment and to keep the copyists from our heels, but patents are not likely to alter whether the innovation proceeds. Finally, there may be areas where products are developed to fill out a line where we have high marketing confidence that even a me-too product would be successful because of exposure, service support strengths, etc. In such an instance, patents may have no role except for defensive considerations of patents of others.

D. Barriers to Use of Patent Systems

In order to explore barriers to the use of the patent system, companies were asked to identify factors that played a role in the decision not to apply for a patent. The primary reason for not applying for possible patents for all sizes of companies was dependency on trade secrets and proprietary technology. For small companies, cost related matters, either obtaining the patent in the first instance or possibly defending it, were important reasons. Also identified by a number of the small companies was the belief that patents were not sufficiently reliable and could be ruled invalid too easily.

If you have technical areas where you have not applied for patents, which reasons are applicable?

	1st	2nd	TOTAL	LARGE
	MAILINGS		SMALL	
Not involved in developing new technology	7	5	12	3
Depend on trade secrets and proprietary technology	43	29	72	17
New technology not patentable	39	8	47	13
Patent rights would belong to other organization or government	28	1	29	1
Patent requires public disclosure	27	17	44	6
Patent protection unnecessary or irrelevant	17	9	26	5
Obtaining patent protection is too expensive	44	18	62	2
Defending a patent is too expensive	32	25	57	0
Patent protection is too unreliable, too easy to get it ruled invalid	33	20	53	2

E. Patent Office as an Information Resource

The patent office is a great storehouse of technical information. In exploring the extent to which companies take advantage of the availability of such information, differences related to company size emerged. Among the smallest companies, less than half use information from the patent office to follow either the technology or their competition. A small majority of the slightly larger companies do use the patent office for information, while almost all of the large companies take advantage of this information source.

Does your company ever use information from the patent office to follow current technological advances?

	Yes		No	
1st Mailing	47	45%	56	53%
2nd Mailing	25	51%	20	41%
Total Small	72	47%	76	49%
Large	21	91%	2	9%

Does your company ever use information from the patent office to follow competitors' activities?

	Yes		No	
1st Mailing	37	35%	57	54%
2nd Mailing	29	59%	19	39%
Total Small	66	43%	76	49%
Large	22	96%	1	4%

F. Alternate Modes of Protection

The chief alternative to the use of patents is reliance on the protection of proprietary know-how and trade secrets. Over 80% of the small companies and almost all of the large companies use these alternate modes of protection. However, in rating the usefulness of these methods, small companies rate them of significantly higher value than do large ones.

Does your company ever employ alternate modes of protection other than patents (e.g. proprietary know-how, trade secrets)?

	Yes		No	
1st Mailing	82	78%	20	19%
2nd Mailing	42	86%	6	12%
Total Small	124	81%	26	17%
Large	22	96%	1	4%

If you also use patents, please estimate the relative value of these alternate modes of protection in your primary field of technology (check one):

A. More useful than patents
B. As useful as patents
C. Not as useful as patents
D. Of little or no use compared to patents

	A	B	C	D
1st Mailing	25	22	16	3
2nd Mailing	15	11	5	1
Total Small	40	33	21	4
Large	0	13	6	3

G. Time and Costs to New Product Introduction

Several questions explored the length of time involved and the extent to which capital is needed for the development and market introduction of new and improved products. The smaller manufacturing oriented companies are the fastest to get new or improved products into the marketplace. They are followed by the smallest, more R&D oriented companies. In general, it takes small companies less than 12 months to bring a product improvement or modification to the market place and less than two years for a new product. By contrast, the large companies indicate over a year for most product modifications and over two years for new product introductions. For the majority of companies, significant amounts of capital need to be invested before such an introduction.

The obvious difficulty for the small companies is the need to obtain outside funding when the costs are too great to finance the development and marketing from current reserves and income. It is not surprising that the smallest companies are in most need of this type of outside funding.

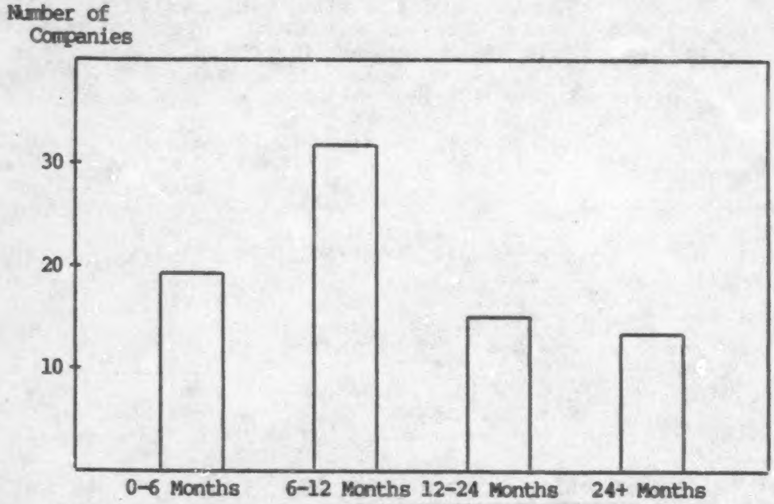


Figure 4.4a Average Length of Time for Product Improvement or Modification to Go from Drawing Board to Marketplace Small Companies - First Mailing

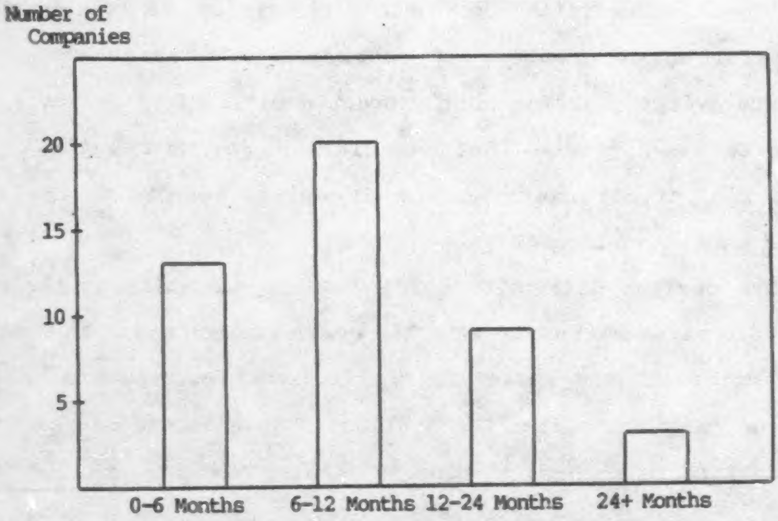


Figure 4.4b Average Length of Time for Product Improvement or Modification to Go from Drawing Board to Marketplace Small Companies - Second Mailing

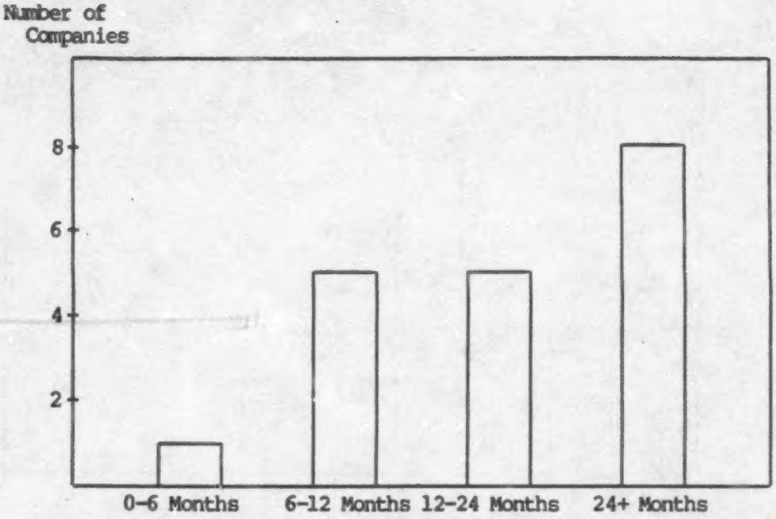


Figure 4.4c Average Length of Time For Product Improvement or Modification to Go from Drawing Board to Marketplace Large Companies

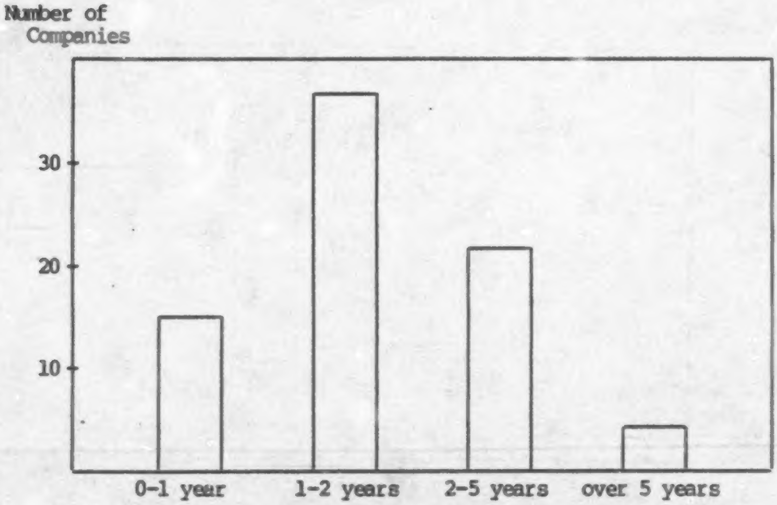


Figure 4.5a Average Length of Time for New Product to Go from Drawing Board to Marketplace Small Companies - First Mailing

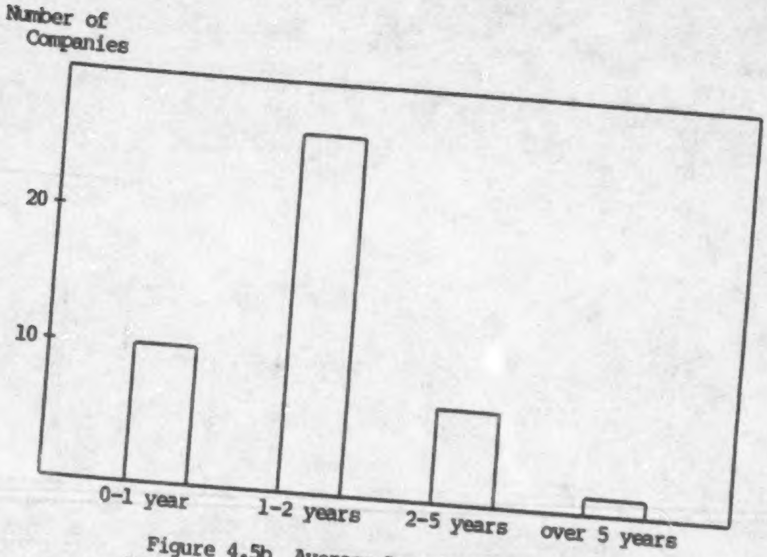


Figure 4.5b Average Length of Time for New Product to Go from Drawing Board to Marketplace Small Companies - Second Mailing

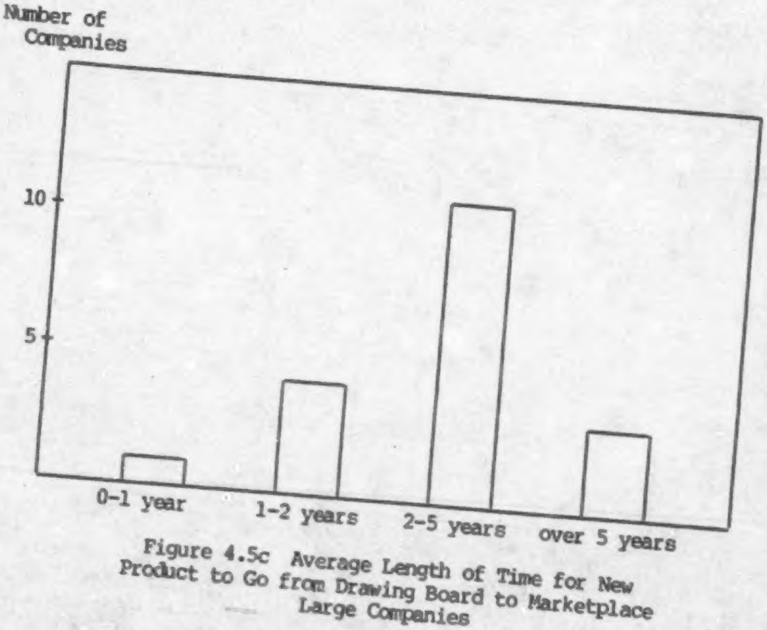


Figure 4.5c Average Length of Time for New Product to Go from Drawing Board to Marketplace Large Companies

How often are major amounts of capital expenses necessary for introduction of product improvement or modification?

	Always		Sometimes		Seldom		Never	
1st Mailing	28	33%	40	47%	11	13%	6	7%
2nd Mailing	7	15%	24	52%	11	24%	4	9%
Total Small	35	27%	64	49%	22	17%	10	8%
Large	5	25%	12	60%	2	10%	1	5%

How often are major amounts of capital expenses necessary for a new product introduction?

	Always		Sometimes		Seldom		Never	
1st Mailing	37	44%	33	40%	8	10%	6	7%
2nd Mailing	13	29%	22	49%	7	16%	3	7%
Total Small	50	39%	55	43%	15	12%	9	7%
Large	8	44%	9	50%	1	6%		

H. Role of Patents in Obtaining Outside Funding

Several questions were asked to determine the extent to which patents play a role in the decision to develop new technology. As was described earlier, patent protection is not the main consideration when business strategy is formulated. However, **when significant amounts of capital need to be invested, most companies view patents as a vitally important or significant factor in the ability to attract outside funding.** This seems to be particularly true for the very small companies who are not yet in a manufacturing mode. **Hence, the existence of patent protection is frequently a vital link in connecting technology with the funds necessary to achieve successful commercialization.**

How important is outside funding in the development of new technology?

	Very		Moderately		Little		Not at All	
1st Mailing	42	57%	9	12%	8	11%	15	20%
2nd Mailing	8	22%	3	8%	9	25%	16	44%
Total Small	50	45%	12	11%	17	15%	31	28%
Company Sales* (in millions)								
0-$.5	17	34%	5	10%	3	6%	7	14%
$.5-$2	21	54%	2	5%	3	8%	5	13%
$2-$5	7	19%	3	8%	4	11%	9	25%
$5-$20	4	22%	2	11%	4	22%	5	28%
over $20	1	14%	0	0%	2	29%	3	43%

*not all companies indicated their size

How important is outside funding in the marketing of new technology?

	Very		Moderately		Little		Not at All	
1st Mailing	27	36%	21	28%	9	12%	17	23%
2nd Mailing	5	14%	4	11%	10	28%	17	47%
Total Small	32	29%	25	23%	19	17%	34	39%

To what extent do patents play a role in the ability to attract outside funding or in the decision to invest funds (for large companies) for the development and marketing of new technology?

A. Vitally important
B. One of many factors considered
C. Of little importance
D. Of no importance

	A		B		C		D	
Small	32	21%	34	22%	9	6%	8	5%
Large	4	17%	16	70%	2	9%	0	0%
Company sales (in millions)								
0-$.5	11	22%	9	18%	2	4%	4	8%
$.5-$2	14	36%	8	21%	1	3%	0	0%
$2-$5	6	17%	7	19%	1	3%	3	8%
$5-$20	1	6%	6	33%	4	22%	1	6%
over $20	0	0%	3	43%	0	0%	0	0%

V. RELIABILITY OF PATENTS AND RELATED COSTS

There has been general concern that small companies with more limited financial resources may be at a distinct disadvantage in defending themselves in a conflict involving patented technology. Several questions were asked to try to determine the extent to which size plays a role in a company's ability to use the patent system fully. While the vast majority of companies estimate patent related expenses as less than two percent of overall expenses, several companies, including two large companies, estimate patent related expenses in excess of ten percent of all costs. There are two distinctly different questions to be decided by a company in relation to the patent system. The first is whether or not to apply for a patent at all. As was seen in an earlier section of this report, certain fields of technology use the patent system more than others. The costs associated with patenting new technology must be balanced with the degree of protection it is likely to provide. Companies carefully weigh the likelihood of having to defend the patent, the probability the patent may be ruled invalid, and the ease with which another company can use the information in the patent and invent around it.

The other decision companies frequently face relates to choosing a course of action when involved in a conflict related to patented technology. About a third of the small companies and all of the large ones have been in such a situation. No distinctions were made in the questionnaire as to who held the patent in question. Some specific questions characterized what happened in terms of types of steps taken, length of time and cost of any action. In general, both the total time for resolution and the cost of resolving conflicts seem to be significantly greater for conflicts involving large companies. Even in our relatively small sample, five large companies cited cases that went to trial and three went to appeals. Interestingly, the one large company that felt the ultimate resolution was unfair indicated their opponent was much larger.

In those cases where companies felt that the resolution of a conflict was not fair, the main reasons stated related to high costs. The only other specific reason referred to an interference case: the company felt that because of the inflexibility of the patent office, the dispute took much longer than necessary to resolve.

Please estimate patent related expenses in the most recent year (in thousands of dollars):

	$0-1		$1-5		$5-20		$20-50		over $50	
1st Mailing	29	33%	33	37%	19	21%	6	7%	2	2%
2nd Mailing	19	46%	8	20%	9	22%	3	7%	2	5%
Total Small	48	37%	41	32%	28	22%	9	7%	4	3%

	$0-10		$10-100		$100-500		$500-1000		over 1000	
Large	0	0%	2	9%	6	26%	3	13%	12	52%

Please estimate patent related expenses in the most recent year as a percentage of total expense:

	0-2%		2-5%		5-10%		Over 10%	
1st Mailing	55	65%	13	15%	11	13%	5	6%
2nd Mailing	35	92%	3	8%	0	0%	0	0%
Total Small	90	77%	16	14%	11	9%	5	4%
Large	18	90%	0	0%	0	0%	2	10%

Has your company ever been involved in any type of conflict situation related to patented technology (e.g., interference, infringement) whether or not any action was taken?

	Yes		No	
1st Mailing	28	31%	62	64%
2nd Mailing	22	48%	24	52%
Total Small	50	37%	86	63%
Large	23	100%	0	0%

Has your company ever decided not to take action in a case where you felt you were right?

	Yes		No.	
1st Mailing	24	52%	22	48%
2nd Mailing	18	64%	10	36%
Total Small	42	57%	32	43%
Large	20	91%	2	9%

If so, rank the following factors in order of importance (#1 most important) during the decision making process in most recent case:

	Ranking							
	1	2	3	4	5	6	7	8
Estimated cost of the action								
1st Mailing	15	3						
2nd Mailing	9	6	1	1	1			
Total Small	22	9	1	1	1			
Large	8	4	3	1	0	1		
Estimated time needed to complete the action								
1st Mailing	0	2	2	5	3	1		
2nd Mailing	4	0	2	2	0	2		
Total Small	4	2	4	7	3	3		
Large	1	4	2	5	1			
Amount of company personnel time that would be needed								
1st Mailing	1	2	6	3	1			
2nd Mailing	4	5	4	1	2	1		
Total Small	5	7	10	4	3	1		
Large	1	4	3	3	1			
Value (monetary or other) to company of positive outcome								
1st Mailing	2	1	2	3	4	1		
2nd Mailing	6	3	0	2	1			
Total Small	8	4	2	5	5	1		
Large	6	3	2	2				

	Ranking							
	1	2	3	4	4	6	7	8
Resources available to other organization involved								
1st Mailing	0	7	4	0	2			
2nd Mailing	1	1	2	2	2	2	1	
Total Small	1	8	6	2	4	2	1	
Large	0	0	1	1	3	4	1	
Inconsistent court decisions in subject area in question								
1st Mailing	0	1	2	0	0	3	2	
2nd Mailing	2	0	4	3	1	1	2	
Total Small	2	1	6	3	1	4	4	
Large	1	0	2	1	3	1	2	
Publicity likely from taking action								
1st Mailing	1	0	2	2	1	0	2	
2nd Mailing	0	0	1	1	0	0	4	1
Total Small	1	0	3	3	1	0	6	1
Large	0	0	0	0	1	2	4	

Have you been involved in any action (court-related or otherwise) as a result of a conflict? Indicate actions taken.

	1st Mailing		2nd Mailing		Total Small		Large	
Involved in Conflict Action	19	18%	15	31%	34	22%	21	91%
Negotiation	12		5		17		13	
Suit Filed	6		6		12		13	
Interference Filed	5		0		5		1	
Discovery	2		2		4		4	
Trial	2		3		5		5	
Appeal	0		0		0		3	

In a recent example, how long from initiation of action to final resolution (in months)?

	0-6		6-12		12-24		24-48		over 48	
1st Mailing	5	30%	4	20%	6	30%	4	20%	0	0%
2nd Mailing	1	7%	3	20%	2	13%	5	33%	4	27%
Total Small	6	18%	7	21%	8	24%	9	26%	4	12%
Large	1	5%	3	16%	5	26%	6	32%	4	21%

Approximately how much did you spend on this matter?

	0-$10,000	$10-20,000	$20-100,000	over $100,000
1st Mailing	15	3	1	0
2nd Mailing	7	1	6	1
Total Small	22	4	7	1
Large	4	3	7	7

Of those large companies that spent over $100,000, four spent less than $500,000, one spent between $500,000 and $1,000,000, and two spent over one million dollars.

In those cases where companies indicated they considered the resolution of the conflict unfair, any comments were analyzed.

	Number of Companies Citing Unfair Resolution	Number of those Cases Where Other Company Larger	Reasons if Cited
Small	12	8	4 cost factors, 2 still unresolved, 1 patent office inflexible (interference) 1 long court and defendant related delays
Large	1	1	

It was expected that small companies would frequently feel at a disadvantage when the other company is large, but it seems the reverse is also true. Large companies often feel at a disadvantage when dealing with smaller ones.

Have you ever felt at a disadvantage when involved in a patent conflict because the other company was larger?

	Yes	No
Small	34	12
Large	3	18

Have you ever felt at a disadvantage when involved in a patent conflict because the other company was smaller?

	Yes	No
Small	1	33
Large	13	9

Have you ever avoided product or technological areas due to cost of defending against possible litigation?

	Yes	No
Small	35	81
Large	8	13

As will be seen later in the report, the imposition of additional patent related fees will cause companies to rethink their patent strategy. Unless the patents are believed to be enforceable, companies will turn more toward alternate modes of protection. This will mean less public disclosure of new technology. Unfortunately, the questions asked to ascertain the extent to which the patent system is perceived as useful and reliable (and hence enforceable) reveal a discouragingly negative view. Companies already are complaining about the cost of defending against possible litigation. **One of the key problems is the view that court decisions related to patent enforcement have been sufficiently inconsistant to make corporate decisions difficult.**

Have inconsistent court decisions ever clouded your decisions on the viability of defending your patent rights?

	Yes	No
Small	37	70
Large	13	9

In your primary field of technology, what percentage of challenged patents would you estimate are declared invalid?

	0-25%	25-50%	50-75%	75-100%	Don't Know
Small	8	15	10	7	28
Large	4	7	2	0	8

Has the company ever experienced a problem with contradictions between patent laws and anti-trust laws?

	Yes	No
Small	9	59
Large	9	11

VI. RELATING TO CONTRACT R&D FOR THE GOVERNMENT

Until the passage of PL 96-517 last December, there was no uniform patent rights policy for companies that performed contract research and development for the government. Each agency had its own rules. The new legislation mandates that small business and universities (with some restrictions) are entitled to such patent rights. However, some background information on the effects of the prior patent policy may be useful in assessing the impact of the new regulations.

Most companies that do R&D under government contract work in their primary field of technology. The majority of the companies that have received commercial patent rights for technology developed under such contracts were doing work for one of the defense agencies. These agencies have a general policy of giving companies commercial rights for work performed under contract to them. **A significant number of companies indicated that past government patent policy inhibited or prevented the application of their most advanced private technology to government sponsored work.**

Has your company ever performed contract R&D for the government?

	Yes	No
Small	81	71
Large	11	12

Was R&D performed for the government done mainly in your primary technical field?

	Yes	No
Small	75	4
Large	8	2

Have you ever obtained exclusive commercial patent rights for technology developed under government contract?

	Yes	No	Don't Know
1st Mailing	19	50	2
2nd Mailing	2	7	1
Total Small	21	57	3
Large	4	7	

Have any attempts been made to commercialize any of your technological developments funded by government contracts?

	Yes	No	Don't Know
Small	40	31	4
Large	5	5	1

Five companies, including one large one, have tried to secure exclusive patent rights for technology developed under government sponsorship and been refused. Of these, three were turned down by DOE, one by DOD and one by NASA.

Do you have patented technology developed under government contract which the government has given or licensed to another organization?

	Yes	No
Small	2	79
Large	2	6

Have you ever had to give background patent rights to the government?

	Yes	No
1st Mailing	12	64
2nd Mailing	1	9
Total Small	13	73
Large	1	9

Have you ever refused a contract because of a background patent rights requirement?

	Yes	No
1st Mailing	5	66
2nd Mailing	1	9
Total Small	6	75
Large	3	7

Has past government patent policy inhibited or prevented the application of your most advanced private technology to government sponsored work?

	Yes	No
1st Mailing	25	65
2nd Mailing	8	31
Total Small	33	96
Large	6	10

One observation indicates an inequity in the way the government has dealt with patent rights decisions. Significant numbers of small companies have undertaken government contract work with patent rights decisions deferred until contract completion. This rarely happens to large companies. A company that cannot be assured of patent rights is hesitant to invest large amounts in filing patent applications. In the words of one respondent: "Neither we nor a licensee will invest in commercialization until we know who owns the patent rights. It is analogous to the situation where a person won't invest in building a house until they know they have clear title to the land."

One difficulty for the small company is that there is only a short time after public disclosure (such as a quarterly report) to file for a patent. In a situation described by one of the respondents: "Decision for granting greater rights to contractor on one invention was never made by the agency--as a result, major aspect of technology reverted to the public because of publication more than one year prior to filing. No further incentive for us to pursue it commercially." This is indicative of the government's insensitivity to the needs of smaller organizations.

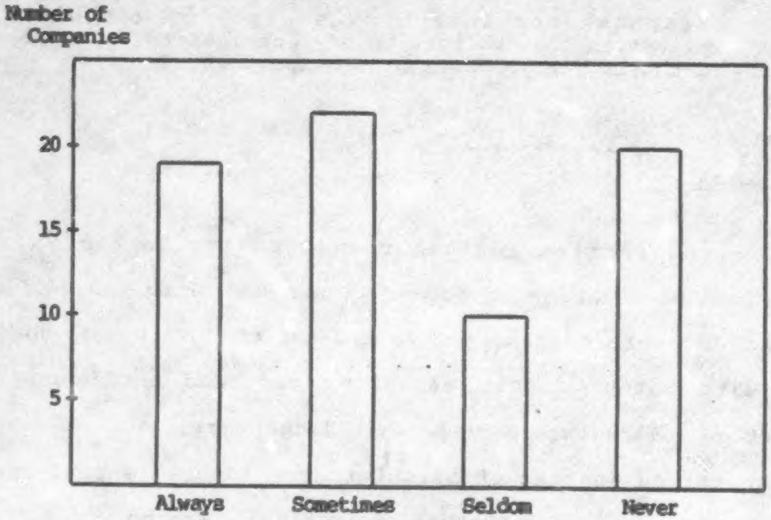


Figure 6a Frequency of Deferral of
Patent Rights Until Contract Completion
Small Companies

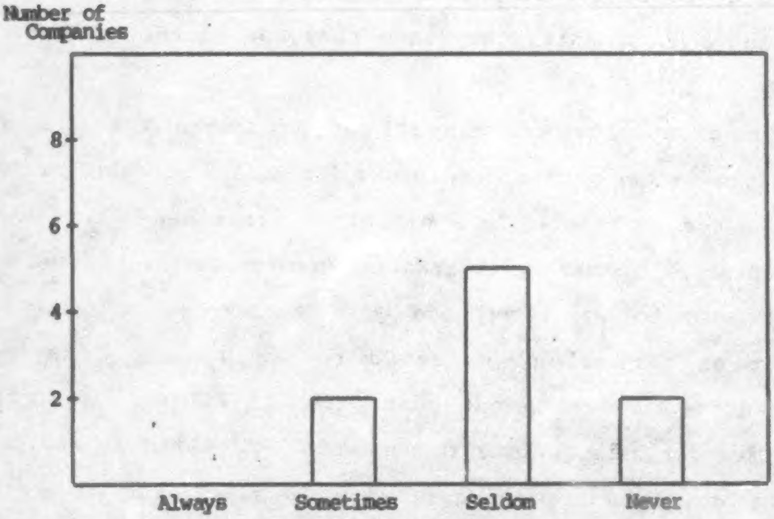


Figure 6b Frequency of Deferral of
Patent Rights Until Contract Completion
Large Companies

Has such a deferred decision ever delayed or prevented you from developing technology for commercial applications?

	Yes	No
1st Mailing	7	43
2nd Mailing	0	7
Total Small	7	50
Large	1	4

VII. MAINTENANCE FEES

Recently enacted legislation includes the introduction of maintenance fees into the U.S. system for the first time. Many European countries already have such fees. Under the new U.S. law, maintenance fees must be paid 3 1/2 years, 7 1/2 years and 11 1/2 years after the patent issues to keep the patent in effect. Otherwise, the patented technology goes into the public domain. It is unclear at what level they will be set, but the legislation also requires a gradual increase in maintenance fees until they pay for at least 25% of the cost of running the patent office. Hence, the eventual fees will be substantial.

At the time the questionnaire was constructed, a maintenance fee schedule of graduated payments of $200, $400 and $800 was being discussed. Those numbers imply a total cost of $1400 to maintain a patent for the full seventeen years. Since this was still a very early discussion, various fee levels were used that placed the $1400 near the middle of the range chosen.

The introduction of maintenance fees means that inventors and companies will have to make a series of decisions related to any given invention rather than one single decision whether or not to patent. The cost of the maintenance fees will need to be added into the other costs already associated with a new patent when weighing the initial decision. **The results of the survey indicate that the balance is likely to tip against patenting much more often.** The company will turn to alternate modes of protection that keep the new technology out of the public domain. In addition, if the patent is not being used actively as it matures, many smaller companies may find the costs of maintaining the patent too great. **Since it is hard to anticipate which patents will be truly valuable, companies may be seriously jeopardizing their future advantage and business.**

During work on this project, there have been many informal discussions with people from both large and small organizations about the patent system. The general concerns about the cost and reliability of patents as well as the possible impact of the maintenance fees were similar to comments received on the questionnaires. One small company stated that the cost of maintenance fees now prevents them from filing European patents. Another mentioned how cost considerations would make bracketing (obtaining additional patents which expand coverage around a single original or base patent) much less accessible. This strategy is very important in some small high technology businesses.

Another small company respondent looked at his company's current level of patent activity of three patents per year or 51 over a 17 year period and deduced the following:

> At $3,000 per patent, we would be liable for $153,000 in fees, or five years' pre-tax profits at the current rate. The effect of any of the mainenance fees mentioned ($500-3000) would be to inhibit the inventiveness of a company currently producing one patent per engineering man year. Our work leads us into advanced technical areas that are generally 5-10 years from the market place. We

> could not afford to keep a patent alive that long before being able to test its market value.

One large company patent counsel with whom I recently spoke indicated that he is looking more carefully at what is patented and is recommending fewer filings. He reasons that in his company a large portion of the legal fees are paid to in-house permanent staff, but maintenance fees are out of pocket. Hence a sharp escalation in those costs makes him think twice about a new patent filing.

While there were many negative comments made about any increase in fees, many also agreed with one small company respondent who said, "We would welcome much higher fees if the fees could buy us a substantially more reliable patent system."

Companies were asked to assume a cost for maintaining a patent for the full seventeen years from $500 to $3000. At each level of costs they were asked what percent of patents they would maintain and whether there would be any realistic impact on their business. The answers to the first quesion are summarized in the charts and graphs on the following pages. The percent of companies that felt maintenance fees would have an impact on their business ranged from 11% at fees of $500 to 39% at fees of $3000. **Over 30% of small companies and over 20% of large companies indicated that the imposition of maintenance fees would make them less likely to apply for a patent in the future.**

> In the following graphs, assume that the dollar value in each is the total cost to maintain a patent for the full seventeen years. Please then estimate the percentage of your current patents you would maintain and whether there is likely to be any realistic impact on your business.

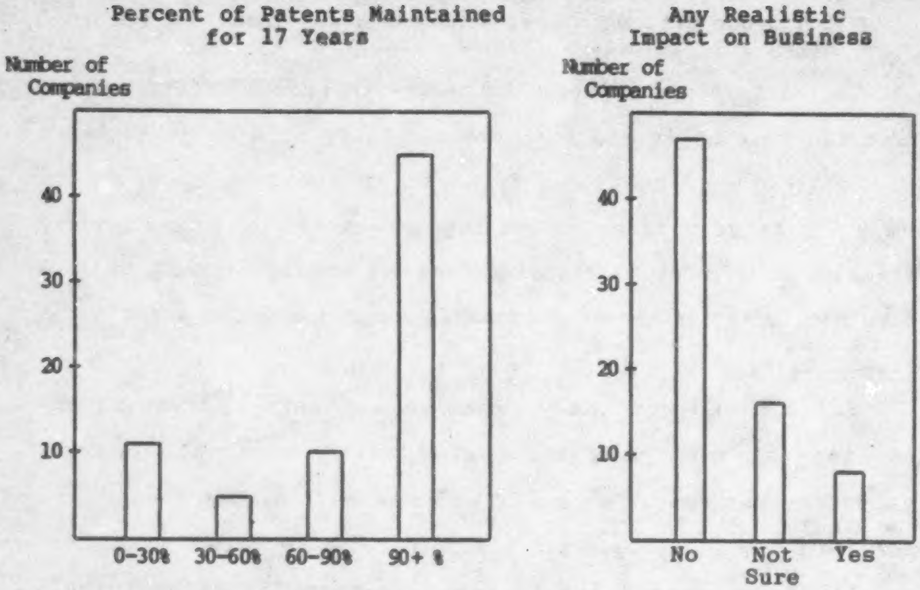


Figure 7.1 Total Maintenance Fees at $500: Small Companies

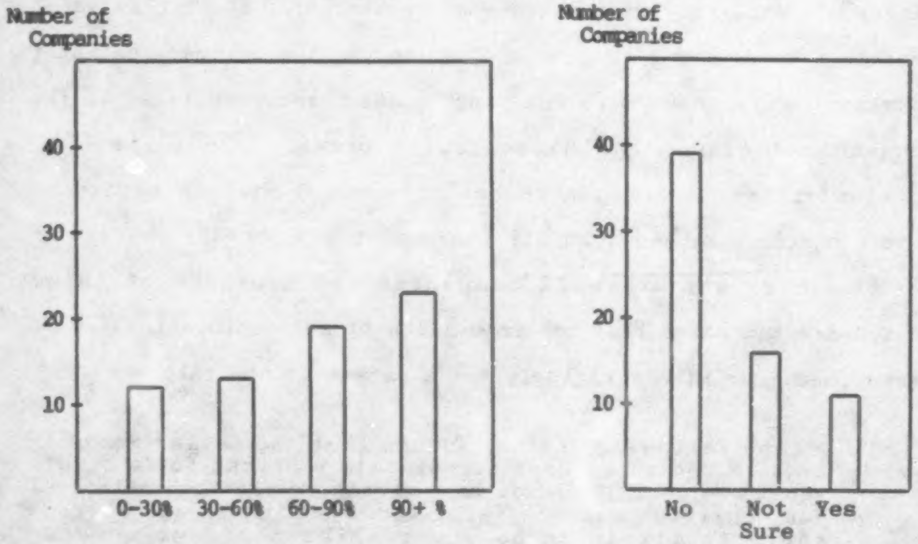


Figure 7.2 Total Maintenance Fees at $1000: Small Companies

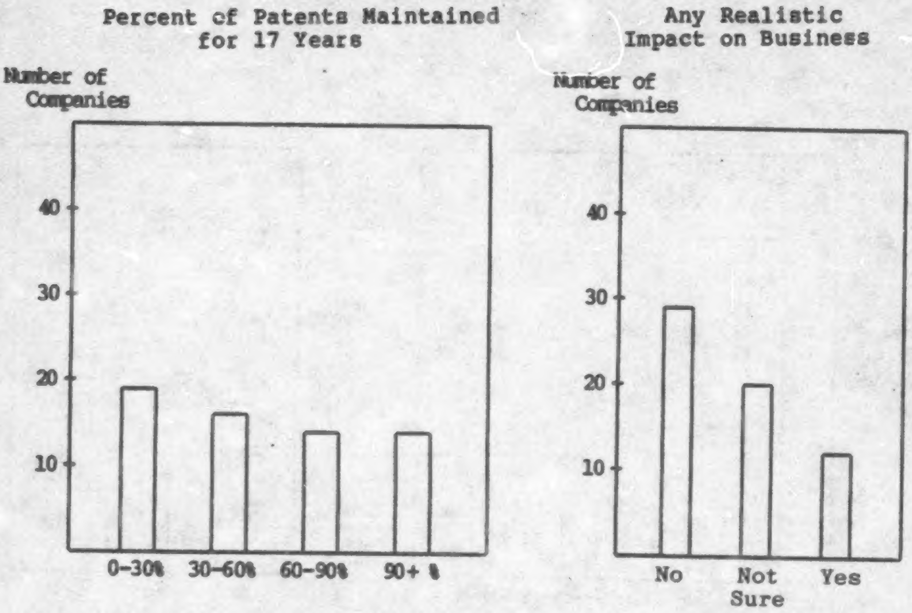


Figure 7.3 Total Maintenance Fees at $1500: Small Companies

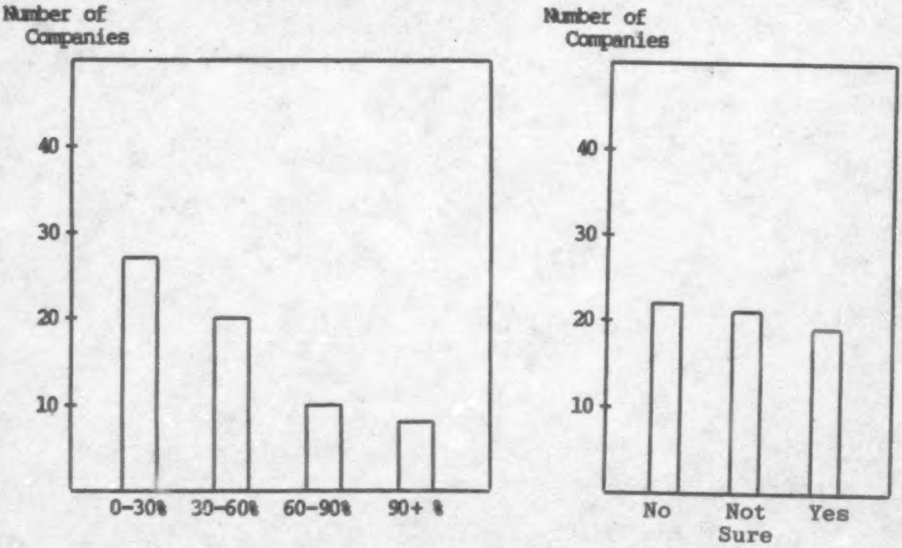


Figure 7.4 Total Maintenance Fees at $2000: Small Companies

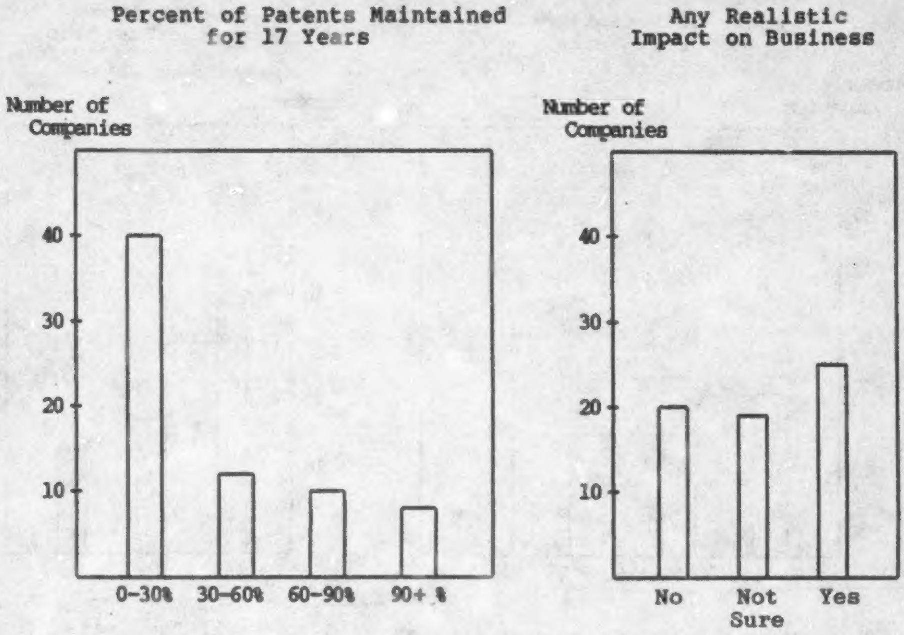
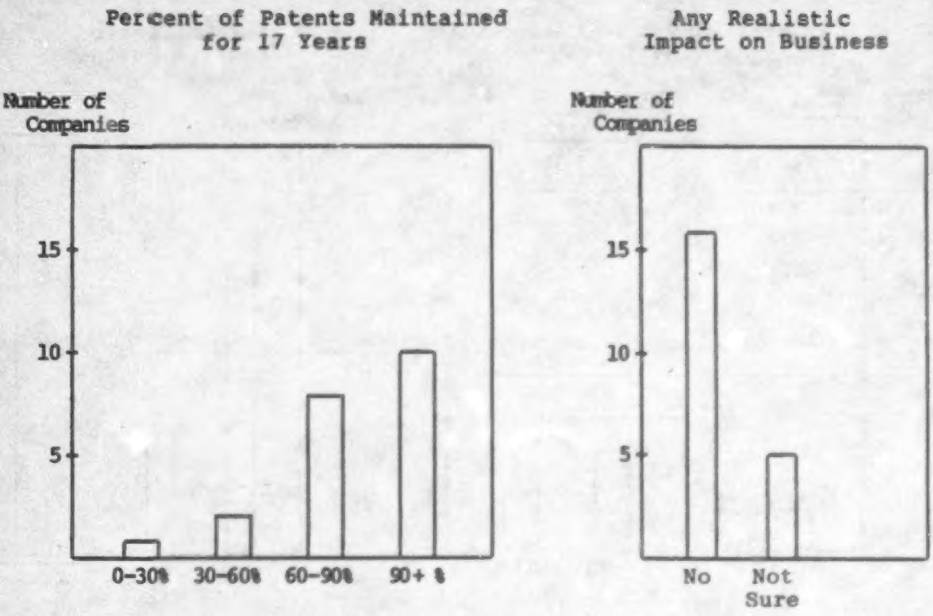
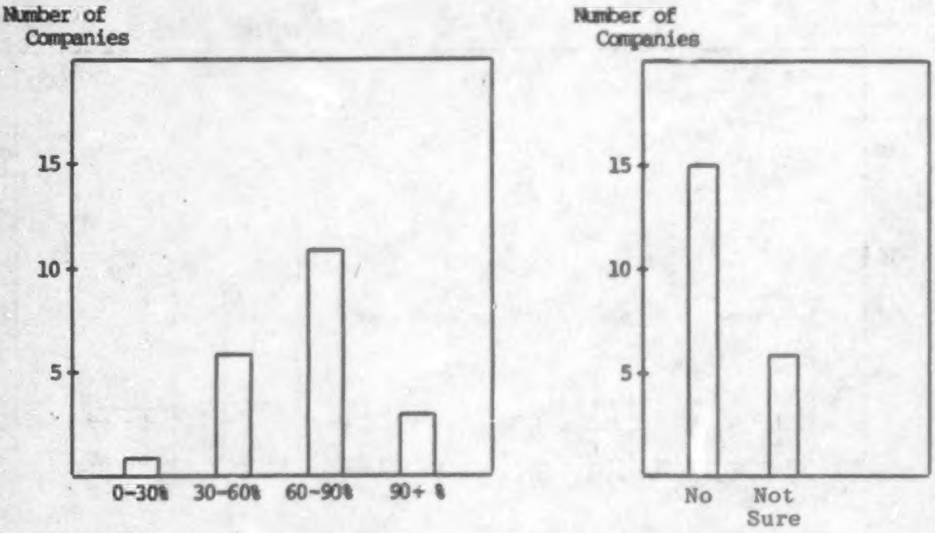


Figure 7.5 Total Maintenance Fees at $3000: Small Companies



7.6 Total Maintenance Fees at $500: Large Companies



7.7 Total Maintenance Fees at $1000: Large Companies

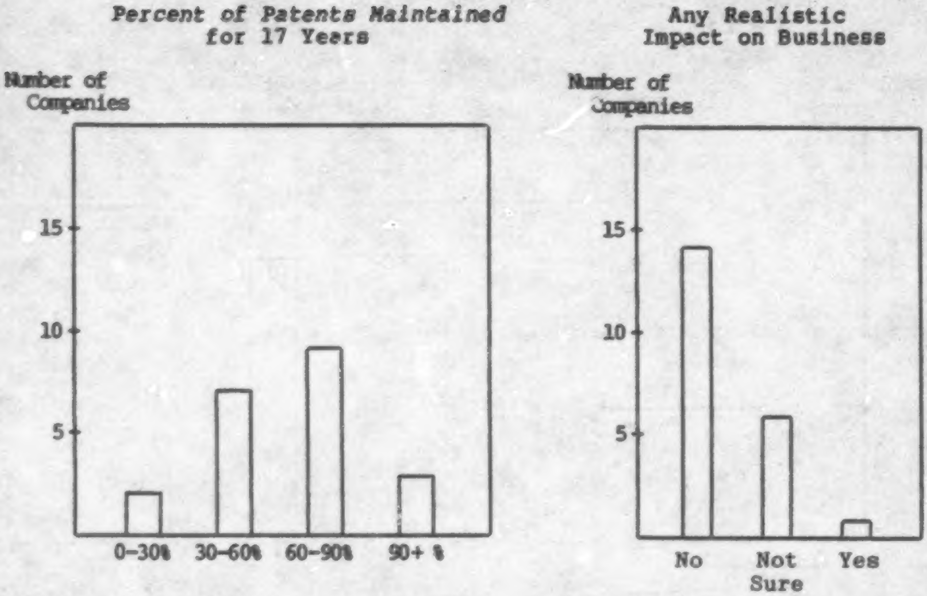
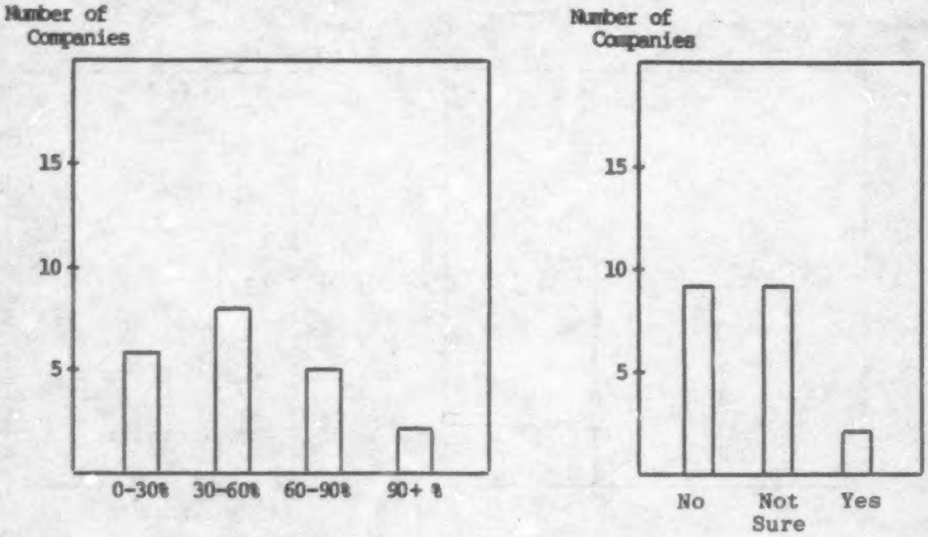


Figure 7.8 Total Maintenance Fees at $1500: Large Companies



7.9 Total Maintenance Fees at $2000: Large Companies

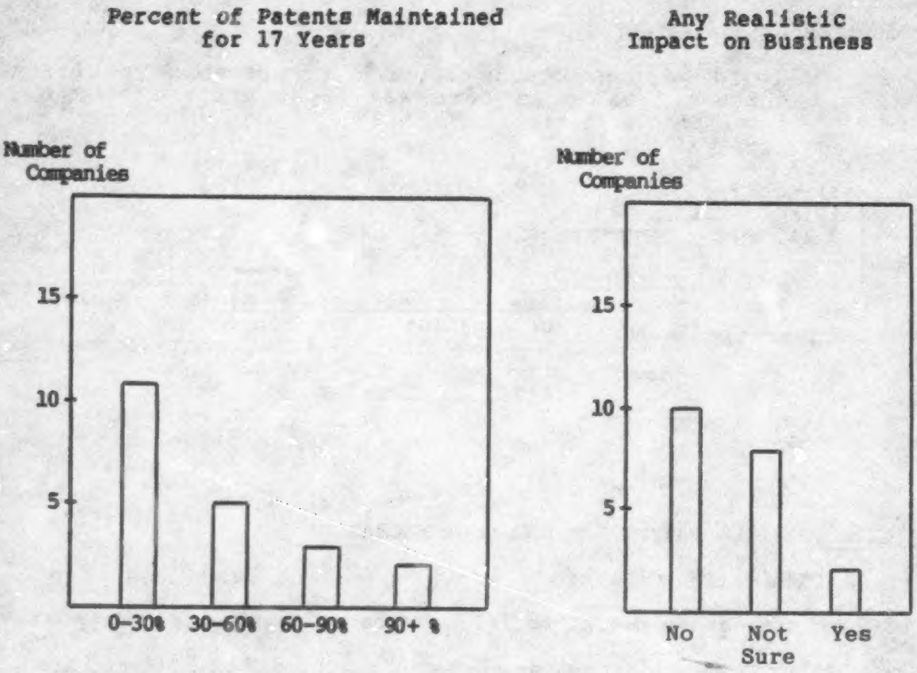


Figure 7.10 Total Maintenance Fees at $3000: Large Companies

Effect on Use of Patent System

Would you anticipate letting any patents you are currently using in some way lapse because of the imposition of fees?

	Yes	No	Not sure
1st Mailing	24	22	18
2nd Mailing	5	1	2
Total Small	29	23	20
Large	7	9	5

Would the imposition of maintenance fees make you less likely to apply for a patent in the future?

	Yes	No	Not sure
1st Mailing	41	21	18
2nd Mailing	5	6	1
Total Small	46	27	19
Large	4	11	5

VIII. POSSIBLE PATENT LAW AND POLICY CHANGES

At the time this study was proposed, a large number of possible changes in patent policy were being considered. Many of the most important changes were passed at the end of 1980 and are part of PL 96-517. Although the implementing regulations are not yet in effect, the new law includes provisions for a patent reexamination procedure, for small businesses and universities to receive patent rights for inventions developed under government sponsored research, and for the institution of maintenance fees.

A number of other changes in the way the patent system operates have been suggested. Respondents were asked for their opinions on a number of them. The overwhelming majority favored the extension of patent life in cases where government regulations delay market introduction, and the establishment of a single Court of Patent Appeals. About half of the small companies and most of the large companies also favor an independent Patent and Trademark Office.

In addition to changes in patent policy already enacted, several others have been proposed. Please indicate which of the following you would favor.

	Yes		No		No Opinion	
Patents should be awarded to the first to file.						
1st Mailing	14	14%	75	74%	12	12%
2nd Mailing	10	21%	30	64%	7	15%
Total Small	24	15%	115	73%	19	12%
Large	11	48%	11	48%	1	4%
Patent life should be extended to twenty years.						
1st Mailing	53	53%	24	24%	23	23%
2nd Mailing	18	39%	18	39%	10	22%
Total Small	71	49%	42	29%	33	23%
Large	10	45%	10	45%	2	9%
Patent life should be extended in cases where government regulations delays market introduction.						
1st Mailing	83	84%	6	6%	10	10%
2nd Mailing	35	74%	8	17%	4	9%
Total Small	118	81%	14	10%	14	10%
Large	19	83%	2	9%	2	9%
A single Court of Patent Appeals should be established.						
1st Mailing	74	73%	2	2%	25	25%
2nd Mailing	32	68%	4	9%	11	23%
Total Small	106	72%	6	4%	36	24%
Large	19	83%	3	13%	1	4%
Attorney's fees in patent matters should be paid by the losing party.						
1st Mailing	47	47%	23	23%	30	30%
2nd Mailing	30	64%	7	15%	10	21%
Total Small	77	52%	30	20%	40	27%
Large	11	50%	10	45%	1	5%
There should be compulsory licensing of patents if the patent holder is using the patent to suppress technology.						
1st Mailing	49	49%	31	31%	20	20%
2nd Mailing	28	59%	11	22%	10	20%
Total Small	77	52%	42	28%	30	20%
Large	5	24%	12	67%	2	10%

	Yes		No		No Opinion	
There should be an independent Patent and Trademark Office.						
1st Mailing	50	51%	4	4%	45	45%
2nd Mailing	22	47%	6	13%	19	40%
Total Small	72	49%	10	7%	64	44%
Large	19	83%	3	13%	1	4%

IX. General Conclusions

In the early days of the patent system, it was customary for the individual inventor to apply directly to the Patent Office for a patent. The process required a minimum of time and expense. Over the years, as the system grew and the use of technology broadened, the patent system grew more complex and expensive to use. It is rare today for an inventor to write a patent application without at least consulting a patent attorney. The process of conducting a patent search for prior relevant technology is expensive, and frequently the strength of the patent depends on the extent of the search. Gradually there has been a movement toward patent system use being limited to those more able to afford it.

Coupled with this shift in who uses the patent system has been the influence of public opinion. The general public is uneasy about patents and seems to look on them as a giveaway to business. There is little understanding or recognition of the importance of patent protection to the nurturing and development of new technology and hence to the economic growth of the country. The ultimate manifestation of this public uneasiness is the attitude of the courts toward patents. Most patent disputes that go to trial are complicated and require a careful evaluation of a technical area. As in most legal proceedings, the answers are not black and white but various shades of grey. The courts, when in doubt, tend to rule against the patent system and declare the patent invalid. The belief is that such a decision will open up the development of the technology to competition, and that is preferred. Since only a few patents are challenged in the courts, the effect on competition is relatively small.

What is not clearly perceived is the chilling effect that these decisions and the attitude they represent have on the use of the patent system as a whole, and on innovation in particular. It is recognized that only valuable patents are cause for a major legal dispute; when people believe that any truly profitable patent is likely to be declared invalid (after a lengthy and expensive court battle), they look for other methods of protecting their technology. If the technological development carries a high risk of failure without an assured protected market position, it may never be explored at all. At the same time, a dependence on other methods to protect technology makes whatever advances have been made in scientific knowledge inaccessable to the public. Technological development is a sequential process with each step building on a number of previous ones. Without the free exchange of knowledge, progress is drastically impeded.

It has been demonstrated repeatedly that the small business sector is a major producer of innovation, especially when radically new, high-risk technology is involved. However, these companies are rarely in a position to completely fund the development and market introduction of their technology by themselves. In order to attract the necessary capital from outside investors, small companies must demonstrate that a protected market niche exists that assures an adequate return on capital invested. Traditionally an important source of that protection has been the patent system. However, a patent system limited more and more to large companies and that affords protection perceived as uncertain at best, leaves the small company in an increasingly difficult position. Substantial costs lead them to seek alternatives to patents such as trade secrets, which in turn reduces their protection in the marketplace, making outside capital investment more difficult to obtain.

This chain of events has clearly been accelerated by the introduction of maintenance fees into the patent system, further weakening the contribution of the patent system to the economic growth and development of the United States. The danger signals and trends are all present in the details of this study.

Perhaps the time has come to reexamine the basis for the existance of a patent system. Do we need a patent system at all? If we do, what should be its functions and goals? How should it be structured to effectively and reliably fulfill those goals? A broad public debate on these issues is a necessary first step. In the last few years, the concern over the decreased rate of innovation in the United States has led to a significant increase in awareness by the Congress of the patent system, its role and its weaknesses. There is still little public understanding of the economic reasons for the existence of a patent system. The result has been a decline in support for the patent system which has gradually become less effective at achieving its original purpose. A patent system that operates ineffectively and themselves. In order to attract the necessary capital from outside investors, small companies must demonstrate that a protected market niche exists that assures an adequate return on capital invested. Traditionally an important source of that protection has been the patent system. However, a patent system limited more and more to large companies and that affords protection perceived as uncertain at best, leaves the small company in an increasingly difficult position. Substantial costs lead them to seek alternatives to patents such as trade secrets, which in turn reduces their protection in the marketplace, making outside capital investment more difficult to obtain.

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APPENDIX A

SURVEY OF THE USE OF THE PATENT SYSTEM

CONDUCTED BY THE RESEARCH & PLANNING INSTITUTE

INSTRUCTIONS:

The following questionnaire has been designed to enable simple check offs for most questions. This means that some questions may not fit your company's situation and you should not hesitate to skip them. If you have been involved in any situation you feel has not been adequately covered by the questionnaire or you had insufficient space for your answers, there is space on the last page for additional comments.

We will be doing follow-ups by telephone of a small number of companies whose response indicates there has been a significant problem and who have indicated a willingness to be contacted.

OPTIONAL (If given, we will send a summary of the results)

NAME: ______________________________

TITLE: ______________________________

COMPANY: ______________________________

ADDRESS: ______________________________

____

TELEPHONE: ______________________________

May we contact you for additional specific information related to your company's experiences?

___Yes ___No

PART I: BACKGROUND QUESTIONS (use most recent fiscal year)

A. Please indicate the sales volume (in millions) for your company
__$0-$.5 __$.5-$2 __$2-$5 __$5-$20 __over $20 millions

B. Please indicate the number of employees
__0-10 __10-25 __25-100 __100-200 __over 200

C. Primary field(s) of technology (be as specific as possible):

D. Age of Company:
__under 2 yrs __2-5 yrs __5-10 yrs __10-25 yrs __over 25 yrs

E. Please estimate what percentage of company expenses were incurred for:
R&D___% Production___% Sales___% Service___% Other___%

F. Approximately what percentage of company sales was made in connection with government contracts and subcontracts?
__None __0-5% __5-20% __20-50% __50-80% __80-100%

G. Location of the company main office:
NE___ MidAtlantic___ SE___ Midwest___ SW___ NW___

PART II: USEFULNESS OF THE PATENT SYSTEM VS. PROPRIETARY KNOW-HOW AND TRADE SECRETS

A. Has your company ever applied for a patent? ___Yes ___No
(If No, go to IIB) If Yes:

1. How many patents does your company hold?
___Less than 5 ___5-15 ___15-25 ___25-100 ___over 100

2. What percentage of these patents is your company actually using in some way?
___Less than 10% ___10-25% ___25-50% ___over 50%

3. How valuable do you think patents are in your company? (check all applicable)
____ Of little value compared with technical know-how
____ Valuable for defensive purposes
____ Important in establishing proprietary position
____ Essential to business activities

4. To what extent do you rely on patents to protect your products?
___Always ___Frequently ___Seldom ___Never ___Does Not Apply

5. How important is outside funding in the development of new technology?
___Very ___Moderately ___A little ___Not at all

6. How important is outside funding in the marketing of new technology?
___Very ___Moderately ___A little ___Not at all

7. To what extent do patents play a role in the ability to attract outside funding for the development and marketing of new technology?
___Vitally important ___One of many factors considered
___Of little importance ___Of no importance
___Does not apply ___Not sure

8. Rate the relative importance of the following factors in the decision to promote new technology (#1 most important):
___Patent Protection ___Market potential
___Proprietary information know-how ___Amount of investment required
___Time required to reach marketplace

B. If you have technical areas where you have not applied for patents, which reasons are applicable?

1. ____ Not involved in developing new technology
2. ____ Depend on trade secrets and proprietary technology
3. ____ New technology not patentable
4. ____ Patent rights would belong to other organization or government
5. ____ Patent requires public disclosure
6. ____ Patent protection unnecessary or irrelevant
7. ____ Obtaining patent protection is too expensive
8. ____ Defending a patent is too expensive
9. ____ Patent protection is too unreliable, too easy to get it ruled invalid
10. ____ Other: ____
11. ____ Does not apply

C. Does your company ever use information from the patent office to:

1. follow current technological advances? ___Yes ___No
2. follow competitors activities? ___Yes ___No

PART II: (continued)

D. 1. Does your company ever employ alternate modes of protection other than patents (e.g., proprietary know-how, trade secrets)?

___Yes ___No

If you also use patents, please estimate the relative value of these alternate modes of protection in your primary field of technology (check one)

___More useful than patents ___As useful as patents
___Not as useful as patents ___Of little or no use compared to patents

2. a. What is the average time it takes your company to get product improvement or modification from the drawing board to the marketplace?

___Less than 6 mos ___6 - 12 mos ___12 - 24 mos
___more than 24 mos ___Does not apply

b. How often are major amounts of capital expenses necessary for such changes?

___Always ___Sometimes ___Seldom ___Never

3. a. What is the average time it takes your company to get a new product from the drawing board to the marketplace?

___less than 1 yr ___1 - 2 yrs ___2 - 5 yrs
___more than 5 yrs ___Does not apply

b. How often are major amounts of capital expenses necessary for such a new product introduction?

___Always ___Sometimes ___Seldom ___Never

4. Pick two products or processes that are, and probably will continue to be, among the most valuable to your company. For each one, please check all those characteristics that best describe your product (or process) and its marketing strategy.

I II
a____ ____ In an established stable market and need to maintain position
b____ ____ In a growth market and plan to grow with it
c____ ____ In a new market area that needs to be developed
d____ ____ Product is protected in marketplace by patents
e____ ____ Product is protected in marketplace by proprietary technology
f____ ____ Product has no legal protection but has brand name recognition
g____ ____ Product is same as others already accepted in marketplace
h____ ____ Product is slightly improved version of product already accepted in marketplace
i____ ____ Product is substantially improved version of product already accepted in marketplace
j____ ____ Product is radically new and/or fundamentally different from previously available products
k____ ____ Little R&D was needed to develop this product
l____ ____ Some R&D was needed to develop this product
m____ ____ Substantial R&D was needed to develop this product
n____ ____ Outstanding R&D was needed to develop this product
o____ ____ Getting product into marketplace quickly was crucial to a successful campaign
p____ ____ Reliability and good performance history more important to success than time
q____ ____ Does not apply

PART III: RELIABILITY OF PATENTS AND RELATED COSTS

A. Please estimate patent related expenses in the most recent year:

1. In dollars:

___less than $1,000 ___$1-5,000 ___$5-20,000 ___$20-50,000 ___over $50,000

2. As a percentage of total expenses:

___Less than 2% ___2 - 5% ___5 - 10% ___over 10%

B. Has your company ever been involved in any type of a conflict situation related to patented technology (e.g., interference, infringement) whether or not any action was taken? ___Yes ___No (If No, go to F)

1. Has your company ever decided not to take action in a case where you felt you were right? ___Yes ___No

If so, rank the following factors in order of importance (#1 most important) during the decision making process in most recent case:

a ___ Estimated cost of the action
b ___ Estimated time needed to complete the action
c ___ Amount of company personnel time that would be needed
d ___ Value (monetary or other) to company of positive outcome
e ___ Resources available to other organization involved
f ___ Inconsistent court decisions in subject area in question
g ___ Publicity likely from taking action
h ___ Other (explain briefly) ______________________________

2. Have you been involved in any action (court-related or otherwise) as a result of a conflict? ___Yes ___No (If No, go to C)

3. Using a recent example of action that has been resolved (or abandoned), please answer the following set of questions.

a. Did you initiate the action? ___Yes ___No

b. List types of action taken (by either party) in chronological order (e.g., negotiation, suit filed, interference action filed, disclosure made, trial, appeal) ______________________________

c. State briefly final resolution: ______________________________

d. How long from initiation of action to final resolution?

___Less than 6 mos ___6 - 12 mos ___12-24 mos
___24 - 48 mos ___over 48 mos

e. Approximately how much did you spend on this matter?

___Less than $5,000 ___$5-$10,000 ___$10-$20,000
___$20-$100,000 ___more than $100,00 ___Not sure

f. What size was the other organization compared to your company (based on sales figures)?

___much larger ___somewhat larger
___about equal size ___somewhat smaller
___much smaller

PART III: (continued)

B. 3. g. Did you feel resolution was accomplished in a fair manner?
___Yes ___No
If not, please explain:______________________________
____
____
____

C. In your primary field of technology, what percentage of challenged patents would you estimate are declared invalid?
___0-25% ___25-50% ___50-75% ___75-100% ___Don't Know

D. Have you ever felt at a disadvantage when involved in a patent conflict because the other company was larger? ___Yes ___No ___Doesn't Apply

E. Have you ever felt at a disadvantage when involved in a patent conflict because the other company was smaller? ___Yes ___No ___Doesn't Apply

F. Have you ever avoided product or technological areas due to cost of defending against possible litigation? ___Yes ___No

G. Have inconsistent court decisions ever clouded your decisions on the viability of defending your patent rights? ___Yes ___No

H. Has the company ever experienced a problem with contradictions between patent laws and anti-trust laws? ___Yes ___No ___Don't Know
If yes, please include a short summary of most recent situation on page 8 where space is provided for additional comments.

PART IV: CONCERNING CONTRACT R&D FOR THE GOVERNMENT

A. Has your company ever performed contract R&D for the government?
___Yes ___No (If No, go to D1)
If Yes:
1. For which specific departments or agencies have you performed work?______________________________
2. Was R&D performed for the government done mainly in your primary technical field? ___Yes ___No If not, what field?__________
____
3. Have you ever obtained exclusive commercial patent rights for technology developed under government contract?
___Yes ___No ___Don't Know
4. Have any attempts been made to commercialize any of your technological developments funded by government contracts?
___Yes ___No ___Don't Know ___Does not apply
5. Have you ever tried to secure exclusive patent rights for technology developed under government sponsorship and been refused? ___Yes ___No ___Don't Know ___Does not apply

If Yes:	most recent situation	other recent situation
a. Which agency or department?	__________	__________
b. Was the technology ever utilized in the commercial marketplace?	___Yes ___No	___Yes ___No
c. If you had received rights, approximately how much investment would you have made to commercialize the technology?	__________	__________
d. Did you go ahead anyway?	___Yes ___No	___Yes ___No

PART IV: (continued)

A. 6. Do you have patented technology developed under government contract which the government has given or licensed to another organization? ___Yes ___No
If so, has that organization received follow-on contracts or hardware orders you expected to receive? ___Yes ___No
What government agency was involved?______________________________

7. Recently enacted legislation gives patent rights to small business and universities for technology developed under government contract. Is this legislation likely to affect your company's participation in providing contract R&D to the government? ___Yes ___No
If Yes, in what way?______________________________
____

B. 1. Have you ever had to give background patent rights to the government? ___Yes ___No If Yes, which agency?______________________________

2. Have you ever refused a contract because of a background patent rights requirement? ___Yes ___No If Yes, which agency?__________

3. Have background rights issues affected company history or decision making? ___Yes ___No If Yes, please explain:__________________
____
____
____
____

C. 1. In your experience, how often is the decision on patent rights deferred until contract completion?
___Always ___Sometimes ___Seldom ___Never

2. Has such a deferred decision ever delayed or prevented you from developing technology for commercial applications? ___Yes ___No
If Yes, please explain:______________________________
____
____
____

D. Has past government patent policy inhibited or prevented the application of your most advanced private technology to government sponsored work? ___Yes ___No If Yes, please explain:______________________________
____
____
____

PART V: MAINTENANCE FEES

Recently passed legislation has authorized the charging of fees to maintain a patent's validity for the full seventeen years (in addition to the patent application fees). These maintenance fees would be due at the end of 3-1/2 years, 7-1/2 years and 11-1/2 years after the date of issue. These fees would be in addition to application fees. Non-payment of any maintenance fees would result in the loss of patent protection.

A. The payment schedule for maintenance fees has not been determined. Would you prefer:
   a. Three equal payments ____________
   b. Increasing payments over time (e.g., 20%, 30%, 50% of total)______
   c. Other (Please explain)______________________________
   ____
   d. No opinion ____________________

PART V: (continued)

B. In the following table, assume that the dollar value at the left is the total cost to maintain a patent for the full seventeen years. Please then estimate the percentage of your current patents you would maintain and whether there is likely to be any realistic impact on your business.

TOTAL PAID IN MAINTENANCE FEES	PERCENT OF PATENTS MAINTAINED FOR 17 YEARS (check one)				ANY REALISTIC IMPACT ON BUSINESS (check one)		
	0-30%	30-60%	60-90%	90-100%	Yes	No	Not Sure
1. $500							
2. $1,000							
3. $1,500							
4. $2,000							
5. $3,000							

C. If at any level there would be an impact on your business, please explain briefly what it would be and whether it would relate primarily to current activities or future activities.

D. Would you anticipate letting any patents you are currently using in some way lapse because of the imposition of fees?
___Yes ___No ___Not Sure ___Doesn't Apply

E. Would the imposition of maintenance fees make you less likely to apply for a patent in the future?
___Yes ___No ___Not Sure ___Doesn't Apply

PART VI: POSSIBLE PATENT LAW AND POLICY CHANGES

In addition to changes in patent policy already enacted, several others have been proposed. Please indicate which of the following you would favor.

A. Patents should be awarded to the first to file. (Currently patents are awarded to the first to invent) ___Yes ___No ___No Opinion

B. Patent life should be extended to twenty years. ___Yes ___No ___No Opinion

C. Patent life should be extended in cases where government regulation delays market introduction (e.g. FDA approval may take five years). ___Yes ___No ___No Opinion

D. A single Court of Patent Appeals should be established. ___Yes ___No ___No Opinion

E. Attorney's fees in patent matters should be paid by the losing party. ___Yes ___No ___No Opinion

PART VI: (continued)

F. There should be compulsory licensing of patents if the patent holder is using the patent to suppress technology. ___Yes ___No ___No Opinion

G. There should be an independent Patent and Trademark Office. ___Yes ___No ___No Opinion

Comments and other changes you would suggest ______________________________

ADDITIONAL COMMENTS (You may attach additional sheets)

FINAL REPORT

CASE STUDIES

EXAMINING THE ROLE OF GOVERNMENT R & D CONTRACT FUNDING IN THE EARLY HISTORY OF HIGH TECHNOLOGY COMPANIES

CONTRACT NO. SBA-2633-OA-79

JULY, 1980

RESEARCH & PLANNING INSTITUTE, INC.
137 MAIN STREET
CAMBRIDGE, MA 02142

The research forming the basis for this report was conducted pursuant to Contract No. SBA-2633-OA-79 from the Small Business Administration. The statements and consiusions contained herein are those of the contractor and do not necessarily reflect the views of the U.S. Government in general or the Small Business Administration in particular.

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Judith H. Obermayer, Ph.D.
Project Leader
Co-Principal Investigator

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CASE STUDIES

EXAMINING THE ROLE OF GOVERNMENT R & D CONTRACT FUNDING IN THE EARLY HISTORY OF HIGH TECHNOLOGY COMPANIES

CONTRACT NO. SBA-2633-OA-79

SUMMARY OF THE RESULTS

This project was to prepare case studies of the early stages of the evolution and growth of thirty-three currently successful, innovative high technology companies. The primary source of information was an interview with a founder of the company. Of particular importance were examinations of the factors integral to their commercial success and the role, if any, played by government research and development contracts in the company histories.

The following seven hypotheses, formulated to help structure the study, were generally supported by the case histories:

Hypothesis 1: A long gestation period is required between the conception of an idea and profitable sales of a high technology invention.

Hypothesis 2: Government R & D contracts provided an important source of cash flow required during the early years of a significant percentage of these high technology companies.

Hypotheses 3: Government R & D contracts provided an important source of funding for the development of technology and expertise used commercially by the company.

Hypothesis 4: Most of the cost of innovation occurs not in the initial research stage, but rather in the later phase of development, manufacturing and marketing.

Hypothesis 5: In those instances where the government was not the ultimate buyer of products developed, government R & D contract money alone was insufficient to accomplish successful commercialization.

Hypothesis 6: Market forces were the critical factor in successful commercialization. Technology push without market forces was insufficient to make a viable business.

Hypothesis 7: The dominance of government R & D contracts in the growth of a high technology company is reduced as a function of increases in firm size during the company life cycle.

The study documents the enormous technological contribution made by these companies toward the solution of our nation's social and economic problems. Their ability to create jobs is significant, even among the older, mature companies that normally produce few new jobs.

The availability of government R & D contracts was frequently an important incentive for companies' formation and a key factor in early survival. But government funding is somewhat erratic and undependable and abrupt changes in government research and procurement policies posed severe problems for many companies in our study. In addition, procurement guidelines and procedures tend to inhibit the kinds of market orientation and business attitudes necessary to commercialize technology.

Some of the other conclusions that seemed significant related to: the importance of funding unsolicited proposals; the prevalence of anti-business attitudes in some government agencies; the strong geographic variations in the use of government R & D contract funds, the use of SBA loans and assistance, the role of universities and the role of venture capital; and the preponderance of companies started by a team of founders rather than an individual entrepreneur.

1. OVERVIEW OF THE PROBLEM AND RESEARCH PLAN

1.1 SIGNIFICANCE OF THE PROBLEM

The lower rate of productivity increase and the serious deficits in international trade experienced by the United States during this last decade are, in part, caused by a decline in industrial innovation. Foreign firms have taken over the technological leadership that previously belonged to U. S. companies in such important industries as auto, steel, pharmaceuticals, consumer electronics, and a number of categories of industrial machinery. These problems affect the value of the dollar relative to other currencies, job creation and the rate of employment, and the standard of living in the United States.

A Domestic Policy Review has been completed in response to President Carter's concern in this area. There is impressive evidence that small firms have made a disproportionately large contribution to U. S. economic growth through technological innovation. An excellent combined source of documentation is the report of the joint Senate/House committees on "Underutilization of Small Business in the Nation's Efforts to Encourage Industrial Innovation", August 9 and 10, 1978.

As an outgrowth of these economic concerns, there has been a great deal of discussion about how to encourage the development and growth of the small high technology company. A number of recommendations have been generated to help improve the current environment for these companies. One such proposal is to set aside a significant portion (for example, 10 percent) of all government R & D funds for small business. Not only might this lead to creative new technologies for direct government use, but it is anticipated that such government funding could lead to technological innovations that would benefit the economy. Other suggested changes deal with such areas as patent rights, procurement regulations and tax incentives. However, it is very difficult to predict the probable impact of these changes and whether they will have any of the desired effect. The most useful guide that can be made available is an evaluation of the importance of various relevant factors for company survival and growth in the past.

1.2 OVERALL RESEARCH PLAN

This project was to prepare case studies of the early stages of the evolution and growth of 33 currently successful, innovative high technology companies. The primary source of information was an interview with a founder of the company. Of particular importance were examinations of the factors integral to their commercial success and the role, if any, played by government research and development contracts in the company histories. Other areas that were explored included amounts, sources and timing of financing, source of the technology, and employment history. The companies that participated are located in the Boston, San Francisco Bay and Milwaukee areas. They were chosen to span a large number of technological fields and were founded between 1946 and 1978. Table 1 shows the geographic and year of founding distribution of the 33 companies included in this study. The selection process, as well as other details of procedure and methodology, are discussed in detail in the section entitled Research Methodology.

1.3 WORKING HYPOTHESES

A number of hypotheses were formulated to focus the research on some specific factors whose relative importance could be examined. It is well known and recently verified again[1] that most companies fall within

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[1] David L. Birch, The Job Generation Process, Cambridge, 1979.

GEOGRAPHIC AREA	YEAR OF FOUNDING 1946-1957	1958-1968	1969-1978	
Boston	6	6	3	15
Milwaukee	1	3	2	5
San Francisco	0	8	4	12
	7	17	9	33

TABLE 1

DISTRIBUTION OF COMPANIES

a short time. This project was to ~~try to identify~~ some of the reasons why one group of high technology companies survived, and whether the government played any significant role in their development. The hypotheses include some issues unrelated to government involvement, which we believe are key elements in achieving the successful commercialization of new technological products and processes. The hypotheses chosen were as follows:

Hypothesis 1: A long gestation period is required between the conception of an idea and profitable sales of a high technology invention.

Hypothesis 2: Government R & D contracts provided an important source of cash flow required during the early years of a significant percentage of these high technology companies.

Hypothesis 3: Government R & D contracts provided an important source of funding for the development of technology and expertise used commercially by the company.

Hypothesis 4: Most of the cost of innovation occurs not in the initial research stage, but rather in the later phase of development, manufacturing and marketing.

Hypothesis 5: In those instances where the government was not the ultimate buyer of products developed, government R & D contract money alone was insufficient to accomplish successful commercialization.

Hypothesis 6: Market forces were the critical factor in successful commercialization. Technology push without market forces was insufficient to make a viable business.

Hypothesis 7: The dominance of government R & D contracts in the growth of a high technology company is reduced as a function of increases in firm size during the company life cycle.

2. ANALYSIS OF THE RESULTS

2.1 TECHNOLOGICAL CONTRIBUTION

Perhaps the most compelling finding is the enormous technological contribution these companies have made toward the solution of our nation's social and economic problems. The majority of companies have, at some time in their history, produced a useful, technologically advanced product or process that has contributed to our country's technical preeminance and economic strength.

One company developed instrumentation that so reduced the speed and cost of blood tests for lead poisoning that large scale screenings are not only possible but now regularly performed throughout the nation. Another company developed an artificial kidney which represented such an improvement over extant methods of kidney dialysis that it is now the most widely used in the nation. This company has subsequently applied the same basic membrane technology to industrial chemical separation. The increased efficiencies of the new processes have reduced costs for industry and opened a new market for the technology with tremendous potential sales and employment. A third example of technological achievement is that of the company whose acoustical engineering work for NACA led eventually to the acoustical design of most commercial jet airplanes and airports. Other companies have developed communication aids for the handicapped, methods for monitoring pollution in the atmosphere, microprocessors for controlling energy usage and waste water treatment equipment. In short, these companies are essential to our nation's technical and economic strength; the importance of stimulating their growth and formation cannot be over-estimated.

The majority of these companies are working on "state of the art" technology and reinvest significant portions of the capital they generate into additional research and development. A number of the founders seemed to be motivated not only by financial rewards, but also by the desire to contribute to the solution of societal problems. If the accomplishments of these companies are a true indicator, substantial progress can be made by nurturing and encouraging the participation of similar companies in the economic life of our country.

2.2 JOB CREATION

The average annual employment growth rate for 30 of the companies in our study from founding to 1979 was a remarkable 30 percent[1]. In the early years of company growth, when the numbers of employees are small, a fairly high growth rate is to be expected. However, there is generally a tendency for the job creation rate to level off sharply as the company matures. While this trend is certainly evident for these companies, the last five years still shows significant job growth. Table 2 shows the employment growth during the last five years. The younger companies have higher growth rates, but the oldest companies still contributed almost half of the new jobs.

One other element should be factored into the total impact of these companies on job creation. Several new companies were spawned from the firms included in our study (see Case 15). Although it is difficult to provide a quantitative measure, it is clear that these spin-off companies also created additional jobs.

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[1] Clear data was not available for three of the companies.

YEAR FOUNDED	EMPLOYMENT 1974	EMPLOYMENT 1979	NUMBER OF ADDITIONAL JOBS CREATED DURING FIVE YEAR PERIOD	PERCENT OF TOTAL NUMBER OF JOBS CREATED	TOTAL PERCENT INCREASE	AVERAGE ANNUAL GROWTH RATE DURING FIVE YEAR PERIOD
1946-1957 7 companies	18,477	26,497	8,020	47.2	43.4	7.5
1958-1968 17 companies	2,048	4,774	2,726	16.0	133.1	18.4
1969-1978 9 companies	3,275	9,534	6,259	36.8	191.1	23.8
TOTAL	23,800	40,805	17,005	100.00	71.4	11.4

TABLE 2

EMPLOYMENT GROWTH

2.3 GOVERNMENT INVOLVEMENT

The case studies clearly document the richness and diversity of experiences technology based companies have with the Federal government in their early years of development. The availability of government R & D contracts was frequently an important incentive for companies' formation and a key factor in early survival. In some cases, government R & D contracts provided an important source of funding for the development of technology and expertise later used commercially by the company. In other cases, the government R & D contracts provided a stable financial base and contributed to the training and build-up of general staff competence and support staff until a clear commercial thrust could be made.

It is also apparent that the availability of government support played a major role in producing technology related to solving societal problems. Government support can come in various forms. One method is to fund the research and development of desired technology, as it is currently done in areas such as health care and solar energy. The government can create a market by subsidizing the consumers of the product, such as equipment for university research laboratories or kidney dialysis equipment. Finally, the government can create a market by issuing regulations that require certain kinds of equipment for compliance. There is a great deal of power available to the government through these various mechanisms and care should be exercised to insure that it is used fairly and wisely.

2.3.1 POLICY CHANGES

Government funds frequently proved to be a mixed blessing. Government funding is somewhat erratic and undependable, and the rules for awarding it, as well as the amount available, can change on a moments notice. Abrupt changes in government research, fiscal and procurement policies have posed severe problems for many of the companies in our study. While certain valid justifications existed for these changes, they are usually promulgated without consideration of the probable effects, either primary or secondary, on the small business sector of the economy. In 1965, the Mansfield Amendment required that Department of Defense funded R & D be mission oriented, i.e., focused on the VietNam War effort. D.O.D. suddenly terminated all long-term research projects. Many companies, even those with excellent performance records, faced wrenching readjustments or bankruptcy (see Case 16).

In the late 1960's, Congress reacted to the disturbances on many college campuses by cutting back funding for university research, especially equipment funds. Several companies in the study sold capital equipment primarily to university facilities. Suddenly they had 50 percent or more of their sales vanish overnight. In our cases, the foreign research facilities kept the companies from failing, but there are probably other companies that did not survive (see Cases 4 and 21).

2.3.2 PROCUREMENT REGULATIONS

Providing R & D services to the Federal government requires very different orientation and strategy from developing a standardized commercial product or service. Companies that have tried to do both and succeeded are rare, most have failed. Those that have succeeded tend to have divided the company activities and responsibilities, frequently using separate divisions or even a subsidiary for one or the other of the areas (see Cases 1, 22 and 25).

Some of the reasons relate to the difference in behavior modes necessary to succeed in government markets as compared to commercial markets. In looking for R & D, the government is primarily concerned with the technology and whether it is of use in highly specialized, non-cost sensitive areas.

The general procurement guidelines and accounting procedures required for government R & D contract sales tend to inhibit the kinds of market orientation and business attitudes necessary to commercialize technology. A number of companies that eventually became extremely successful commercially did so by acquisition and not by pursuing the technology they had developed under government contract. Some of the problems are the following:

1. Many government agencies will not give a company exclusive rights to patents developed under contract.
2. Market research is not an allowable overhead expense.
3. Limits on allowable bid and proposal expenses and Independent R & D expenses are unreasonably low, especially for a new company.
4. Interest paid on money borrowed is not an allowable overhead expense (even when it is due to the government's delay in paying its bills).
5. Cost sharing is often required.

Another problem related to government policies is the insensitivity of many government agencies to technological changes and improvements. Procurement specifications often include the design criteria as well as those for performance. Bureaucrats are frequently intransigent in their rejection of the new in favor of safer known products or processes even where the new products promise to be 100 percent better. In several instances, companies have been forced to go abroad to gain acceptance for products that would have been of great benefit to the United States (see Case 7).

2.3.3 UNSOLICITED PROPOSALS

The importance of the government's willingness to fund unsolicited proposals was mentioned repeatedly. When companies come up with creative new solutions to existing problems, it is through the funding of an unsolicited proposal that these new ideas can be explored and tested.

Several of the companies developed significant new areas of technology useful both to the government and to society through government funding of unsolicited proposals, especially in the 1950's and early 1960's. The technical development generally took several years and while results continually flowed out and were evaluated, the projects were funded with long-term results as the goal.

Unfortunately, in recent years this source of funding has almost completely disappeared. If the proposed research does not fit into a well defined segment of the current research strategy of a government agency, no mechanism exists to permit its funding, regardless of its merit. Companies can survive by providing incremental information and developing the appropriate instrumentation to move along an existing, government supported technology. But the radically new ways of solving problems are not given a reasonable chance to prove their validity. The current climate, with its tight R & D budgets that must be defended as mission related and the propensity, when in doubt, to give money out in large segments to well known companies, all work against the development of new, exciting technical advances.

2.3.4 DIRECT SUPPORT AND ASSISTANCE

A small number of companies in the study made use of SBA loan guarantees. Most viewed such loans as unable to meet their needs and never considered applying. Several companies provided testament to the positive results obtained in exporting through the aid of the Department of Commerce. Several mentioned the importance of both the encouragement received and the subsidy available for attending international trade shows. One company mentioned the excellent help received through the SBA SCORE and ACE programs.

2.3.5 ANTI-BUSINESS ATTITUDES

One problem that came up several times was the inability of small business to receive basic research support from certain agencies, especially NSF and NIH, which primarily fund research at university and non-profit institutions. In fact, their ideas are not even given a fair hearing. One company, that wished to gain support for basic research to better understand the scientific underpinnings of its technology, created a non-profit laboratory facility. The non-profit institution was able to obtain basic research funds to pursue the originally proposed research. While most people were in favor of government support of basic research, there was resentment that in those cases where a profit making business could do the work better than another institution at no additional cost, it still was denied the opportunity to do so.

2.4 EVALUATION OF WORKING HYPOTHESES

As part of the proposal for this research project, several hypotheses were formulated. This section contains a discussion of the extent to which each was confirmed or rejected by the study.

Hypothesis 1: A long gestation period is required between the conception of an idea and profitable sales of a high technology invention.

For the companies where relevant information is available, the hypothesis is strongly supported. The following are examples taken from the case studies:

"In 1965, it was decided to try to produce a tracer to allow a machine to make copies of complex tools ... However, it was several years before this tracer was accepted by industry."

"The founder ... had been looking for a good product idea, and in 1969, started working on a specific product in his basement... It took over three years to perfect the technology sufficiently to begin real operation of the company."

"While the company began to develop some marketable instrumentation within a year of founding, many aspects of the companies permeation and liquid chromatography took considerably longer to develop."

"Despite the companies tremendous R & D expenditures, many of the founders original ideas (founded in 1946) are just now coming to fruition while others could remain in the research stage far into the future."

"In 1972, the company decided to develop a commercial product in the gas analyzer business and introduce it on the market. In 1973, the company made the first sale of the product. The company tried to enter the auto emission market in 1974, but the product didn't gain acceptance until 1979."

"Even though the company was formed in 1965, they didn't make their first major delivery of a product until October, 1967."

Hypothesis 2: Government R & D contracts provided an important source of cash flow required during the early years of a significant percentage of these high technology companies.

15 of the companies relied on government funding in their early years for more than 50 percent of sales, with 14 companies counting on this source of funds for more than 75 percent of their sales. As an average, government funding, both direct and indirect, accounted for 46 percent of sales. These sales figures were derived from first year sales. If first year sales amounted to zero, the first year when the company made a sale was used as a reference point.

Hypothesis 3: Government R & D contracts provided an important source of funding for the development of technology and expertise used commercially by the company.

22 of the 33 companies examined noted that government R & D contracts provided an important source of funding for the development of technology in terms ranging from "crucial" to "indirectly so",

with a preponderance of replys on the crucial side of the spectrum.

Hypothesis 4: Most of the cost of innovation occurs not in the initial research stage, but rather in the later phase of development, manufacturing and marketing.

Most of these firms have experienced great difficulty going from the research stage into the development, manufacturing and marketing stage. Six of the companies either sub-contract their manufacturing or simply avoid it altogether, choosing to do only R & D. All of these firms cite costs as the reason they chose not to go into production. Of the companies that now do their own production, virtually all cited the crippling transition between R & D and bringing a product to the market. A reading of the individual cases makes the situation clearer, especially when you consider that time means money.

Hypothesis 5: In those instances where the government was not the ultimate buyer of products developed, government R & D contract money alone was insufficient to accomplish successful commercialization.

This was difficult to measure since money earned on one project could be used to fund other activities for the company without a clear identification of what happened. Also, outside capital frequently was used to deal with cash flow problems. Nevertheless, one measure of financial need is how much capital was obtained.

Of the 33 companies examined, 16 of these received capital from the founder(s).

13 of the 33 used some form of venture capital at least once.

16 of the 33 have gone public, with 8 of these 16 attributing a need for additional capital as the main reason.

Hypothesis 6: Market forces were the critical factor in successful commercialization. Technology push without market forces was insufficient to make a viable business.

Of the 32 companies addressing this question, 28 of these firms pointed out the importance of market forces in the company growth. Four of the companies point to their unique technologies as reason for success, but two of these firms cited a lack of a defined market as being an obstacle that caused severe problems, and a subsequent reappraisal of values. Several companies were formed by founders who identified a market need first, proceeded to put together the technology necessary to provide what was needed and finally go on the market with it. A number of these companies were successful in a relatively short period of time (see Cases 3, 24, 33).

Hypothesis 7: The dominance of government R & D contracts in the growth of a high technology company is reduced as a function of increases in firm size during the company life cycle.

Today only 10 of the 33 firms rely on government business, direct or indirect, for more than 50 percent of their sales. This contrasts with 15 of the companies relying on more than one-half government work in their first year of sales. Only 6 of the 33 companies today rely on government business for more than 75 percent of their revenues, as opposed to 14 companies relying on more than 75 percent government work in their first year of sales.

2.5 GEOGRAPHIC VARIATIONS

Several characteristic differences emerged between the three regions. The most striking is the role of government R & D contracts. By looking at Table 3 Sources of Technology, it is immediately apparent that the vast majority of the Boston area firms used technology from university laboratories and developed with Federal research and development grants and contracts. The companies in the San Francisco area used some Federal research money, but only one from Wisconsin did, and that was not for its initial product. There was evidence of general reluctance in the Milwaukee area to use government contract funds. On the other hand, it was the Milwaukee area firms that made use of SBA loan guarantees and other kinds of government assistance programs.

In the Boston area, several of the firms received some of their early financing from the same venture capital firm. This firm specialized in providing high risk money to innovative high technology companies that could potentially make a significant contribution to both society and the economy. One founder specifically made reference to the importance of this source of "patient money," an investor who understood how long it takes to get new technology to pay off.

On the other hand, the Milwaukee area companies rarely made use of venture capital sources to finance their business growth. It is not clear whether this source is simply not available generally, not available for innovative companies, not acceptable to the founders or our sample was unrepresentative. Sources of capital generally used were founders and their relatives, bank loans, and, in some cases, the public market.

	TOTAL NO. OF COMPANIES	UNIVERSITY RESEARCH NO.	UNIVERSITY RESEARCH %	GOVERNMENT SPONSORED RESEARCH NO.	GOVERNMENT SPONSORED RESEARCH %	PREVIOUS INDUSTRIAL EMPLOYER NO.	PREVIOUS INDUSTRIAL EMPLOYER %	OTHER NO.	OTHER %
Boston	15	9	60	12	80	6	40	0	0
Milwaukee	6	1	17	0	0	2	33	3	50
San Francisco	12	2	17	5	42	7	63	3	25
FOUNDED									
1946-1957	7	5	71	5	71	2	29	0	0
1958-1968	17	4	24	9	53	8	47	4	24
1969-1978	9	3	33	3	33	5	55	2	22
TOTAL	33	12	36	17	52	15	45	6	16

TABLE 3

SOURCES OF ORIGINAL TECHNOLOGY

2.6 PERIOD OF FOUNDING VARIATIONS

The most obvious difference between the companies founded in various periods was the use of government R & D funds. Most of the companies founded before 1963 had a significant proportion of government sales in their initial period. 62 percent of them had government sales of at least 80 percent for the first year of sales. Of the companies founded in 1963 or later, only 25 percent had government sales of over 50 percent in the first year.

2.7 UNIVERSITY INVOLVEMENT

In an extraordinary number of cases a university played a major role in the history of the company. There were a number of companies started to pursue the results of research done at universities, although generally a significant amount of development work was still required. Often, the original research was performed under government grants. In other cases, especially apparent at MIT, the university encouraged faculty members to do outside consulting work for industry. When the consulting work begins to mushroom, colleagues or students are recruited to help and soon a company is born.

For companies in extremely advanced technologies, a continuing relationship with the academic community not only keeps the senior staff informed of new research developments, but helps the company acquire the most competent technical personnel.

2.8 FINANCIAL RESOURCES

A large number of the cases studied required several infusions of capital as they grew. Most of the capital in the early years was to fund research and development or to cover cash flow when sales grew very rapidly. Founders talked repeatedly of the difficulty in raising capital, especially for the very high risk early stages. Table 4 shows a summary of the total amount of capital investment by region and year of founding.

The sharp increase in the Federal capital gains tax during the early 1970's had an indirect but pervasive and deleterious effect on the high technology small business sector of the economy. During the 1960's, considerable high risk financing was available for high technology start ups. This supply was due in part to the existance of a large public market for high technology company stock through which the venture capitalist could easily recover his investment. With the increase in the capital gains tax, the market for new stock issues essentially disappeared, leaving the venture capital community with no means for recovering investments. As a result, venture capital avoided high risk ventures in favor of "sure bets" thereby eliminating supplies of early financing for high technology companies. During the early 1970's high technology company formation activity dropped close to zero nationwide.

In the words of one of the founders of a successful, mature company:

> Most companies that fail do so because they don't have enough money to get off the ground. Venture capital is hardly going to risk its funds when IRS will take away any return it gets on its investment. The recent reduction in the capital gains tax should help, but not enough. So many good ideas are lost because no one is willing to put up the money necessary to develop them.

Founders complain that under the present situation, if they wish to sell the company, they are almost forced to sell to a public company so

	UNDER $100,000	$100,000 to $1 Million	$1 Million to $6 Million	OVER $6 Million
Boston	5	5	4	1
Milwaukee	4	2	0	0
San Francisco	0	7	3	1
FOUNDED				
1946-1957	1	2	3	1
1958-1968	4	9	3	0
1969-1978	4	3	1	1
	9	14	7	2

TABLE 4

AMOUNT OF TOTAL INVESTMENT TO DATE

Based on those companies where total was known or could be estimated they can carry out a tax free exchange of stock.

2.9 INDIVIDUAL FOUNDER OR TEAM

It was observed that many of the most successful companies were started by a team of founders. This seemed to produce more willingness to use the knowledge and experience of various people and to pull in business and management help as needed. This contrasted with the individual founder who sometimes was unwilling to relinquish control of any aspect of the business, even where he had limited experience. In general, the companies that achieved commercial success had someone as part of the management team who was oriented toward management and marketing and not simply a technologist. Table 5 shows the preponderance toward team founders, especially among the larger firms.

2.10 EXPORT SALES

The data we received related to export sales was somewhat incomplete. We do know that seven of the companies do at least 20 percent of their business overseas and a minimum of 13 of the companies have some overseas sales. The companies most active in export activities sell state of the art high technology products in such fields as medical and scientific instrumentation, electronics and telecommunications.

CURRENT SALES	NUMBER OF COMPANIES	TEAM FOUNDERS	INDIVIDUAL FOUNDERS
≤ $ 5 Million	14	7	7
$6 - 20 Million	9	9	0
$21-100 Million	6	4	2
≥ $100 Million	4	3	1
	33	23	10

TABLE 5

INDIVIDUAL OR TEAM FOUNDERS

3. POLICY RECOMMENDATIONS

There are a number of changes in Federal procedures, policies, and regulations that could greatly improve the ability of innovative high technology companies to contribute to the technical needs and economic strength of the United States. It is clear from the companies we examined, that the availability of R & D contract funds and other government supported sales opportunities does provide an incentive for the establishment of new firms. In return, the small high technology company frequently does an outstanding job of solving difficult technical problems for the government. If the aim is also to encourage companies to establish a viable commercial business and get their technology into widespread use, then changes, especially in government procurement policy and capital formation areas are critical.

The following recommendations are based on the results of the cases studied:

1. A significant proportion of government research and development contracts in all agencies should be set aside for small business. Provisions should be included for the funding of some unsolicited proposals.

2. Procurement attitudes and regulations should be changed to be more consistent with standard commercial business practices and to remove the problems listed earlier in Section 2.3.2. Whenever possible procurements should be awarded on the basis of total price and a set of performance standards, not on how the company's accounting

is done. Contract requirements and auditing procedures should be commensurate with the size of the contract.

3. An effective mechanism needs to be developed to provide accurate assessments of the probable impact of proposed policy and regulatory changes on small business. Such assessments should include possible secondary effects and recommendations to alleviate hardship.

4. Tax incentives for investors to provide high risk, early funding for small high technology companies should be increased. It is necessary to make the rewards sufficient to attract investors away from other lower risk, high reward investments such as real estate.

5. Mechanisms should be established for a founder or early investor to sell out to another individual or small company rather than to a large public company without disasterous tax consequences.

4. RESEARCH METHODOLOGY

4.1 SELECTION OF COMPANIES

The proliferation of high technology companies in the Boston and San Francisco areas made them logical areas for inclusion in the study. The Milwaukee area was chosen as a representative region where the number of successful high technology companies is much smaller, although there is a considerable amount of industry. The fact that our company is located in the Boston area and we were able to obtain the services of competent subcontractors to carry out the field work in San Francisco and Milwaukee clearly contributed to our choice of geographic regions.

Using several local resources, as well as a number of companies known to us personally, a list of possible companies was compiled for each region. Information on their year of founding, field of technology, government involvement, current sales, etc., was gathered from many informal sources to form a profile of the company. A number of companies were eliminated when it became clear that a founder would not be available for an interview or the initial information was too limited to be useful. Several companies were selected as first priority because of known government involvement, innovative activities, and close personal contacts with founders. Additions were made to the list based on covering the broadest range of company characteristics possible. The characteristics considered during the selection process included:

field of technology -- Included electronics, computers, energy, chemicals, food technology, optics, medical instrumentation, pharmaceuticals, etc.

year of founding -- divided into three general eras, post World War II to Sputnik (1957), Sputnik to late 1960's, and from late 1960's to present.

markets currently served -- included commercial, government both general and military, and foreign.

government R & D funding -- included both civilian and military agencies.

type of products -- included service, proprietary product with patent protection, specialty, consumer, industrial.

Very few founders refused to participate in the study, although scheduling difficulties sometimes made it necessary to eliminate a company.

4.2 INTERVIEW WITH FOUNDER

Interviews were generally conducted by teams of two people which provided several useful advantages and safeguards. Most interviews lasted one to two hours. One person directed the discussion to the most salient points, concentrated on follow on questions and made sure that all aspects of concern were covered. The other acted as observer and recorder so that when the interview was concluded, all important information was ready for the next step. In addition, a more accurate interpretation of what was meant is likely when two people can compare impressions and facts gathered earlier. The person to be interviewed was sent a letter explaining the study and its areas of interest. In many instances, we were able to obtain some historical information about the company before the interview.

4.3 INFORMATION ORGANIZATION AND CASE STUDY PREPARATION

The information obtained from both general sources and the interview was organized in several ways. First, a questionnaire form was filled out which organized the information by specific categories:

Founders
Funding History
Technological History and Investment
Sales and Market History
Employment History
Key Factors and Events

This process was most useful for recording factual and numerical information and formed the basis for the tables in this report.

The information provided about each company was put into a narrative form so that not simply numerical facts, but also the relative significance of various factors and key events could be put in proper perspective. Company identities were protected by generalizing the information, especially the specifics of the technology. The format chosen after consideration of several alternatives, consists of the following sections:

Company Development and Technological History
Financial History
Sales and Employment History[1]
Government Involvement
Significant Events and Key Factors

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[1] In the case studies, Indirect Government Sales are defined as sales to a non-governmental organization where the funds used to purchase the product/service are supplied by the government.

4.4 ANALYSIS OF THE RESULTS

Most of the numerical information which lent itself to tabulation appears in the Tables. A discussion of the major findings including some more subjective and less quantifiable results, as well as conclusions about the original hypotheses of this study appear in Section 2. Discussions were held among the principal interviewers to exchange perceptions about the information obtained and other less tangible factors, and to see whether isolated anecdotal information had more general significance. Although the nature of a set of case studies implies limited, individualized information, the analysis performed was aimed at providing an overview of the company histories. The goal was to identify some of the factors most critical to success, as well as ways in which changes in government policy could encourage the formation and growth of these companies.

5. THE CASE STUDIES

CASE #1

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1968 to pursue two basic lines of research and development. The first related to basic pumping technology, with particular attention to the medical area. The second research area of interest related to gas spectrometers. The two focuses have remained, and today are reflected in the corporate organization. Of the four founders, however, only two remain with the company; one heading each of the company's two divisions.

Within six months of its founding, the company had its first government sponsored R & D contract. It is apparent the founders of this company had entered preliminary negotiations relating to this contract while with their previous local R & D employers. The nature of the contract, while not directly competitive, was an outgrowth of the research conducted while with these previous employers.

Following the initial R & D contract in 1969, the company continued as a largely government sponsored R & D service operation until the 1971-1972 period. At this point, the company experienced severe financial pressures as a result of one particular contract. This one difficult experience almost put the company out of business and brought about some significant changes in the organization and its business philosophy. In 1972, the company finally decided to develop a commercial product in the gas analyzer business and introduce it in the market. The company also changed its name and experienced its first profitable year of operations.

In 1973, the company made its first sale of their gas analyzer product. This initial sale eventually lead to a licensing/royalty arrangement with a major firm and has provided a positive cash flow that has been highly beneficial to the overall operation.

Based on their initial success in the gas analyzer product area, the company attempted to enter the auto emission market in 1974. Unfortunately, this product did not gain wide acceptance until the 1979-80 period, when the company began to sell their product to the automotive OEM market for incorporation into larger units.

The two product lines reflect in many ways the character of the founders that run them. The medical pumping technology has remained largely a research type organization, relying on R & D contracts with only minor efforts toward developing a commercial application. This division has relied on in-house technology and its growth has been slow.

The gas spectrometer business has been more aggressive in developing specific products with commercial potential. In this case, the division has relied heavily on specific recruiting efforts to speed up the growth of technology. Growth in this division has been spectacular in the last few years, after a slow start.

FINANCIAL HISTORY

The company's initial financing was $250,000 in private equity funds. In 1972, there was a change in the equity position of the company that reflected a desire on the part of the original investors to achieve some degree of liquidity rather than a significant change of ownership. This transaction, nevertheless, resulted in another $250,000 of new equity monies.

By 1976, the company's combined sales had reached the $1 million level and the original investors were called upon to put in an additional $100,000 in equity money. These funds were used to help cover the cash flow needs of the company.

In 1979, the company's sales had reached the $2 million level and the original investors were once again called on for an additional $200,000 in equity money. This last investment brought the total equity participation to $800,000. All other financial needs have been met through debt financing. It is anticipated the 1980 sales level should reach $8.0 million, and is largely reflective of the sales growth in the gas analyzer product line. At this time, outside investors hold 80 percent of the company with the remaining 20 percent held by employees (this includes stock options).

The company has a small equity base for a company of this size, and has relied heavily on debt financing for their growth needs. This has not been easy, the banks have often asked for guarantees from the financial backers, which the financial backers have refused to give. The result has been very difficult in terms of shopping around for operating capital, often being in the position of having to take less than favorable conditions. The company did not feel they would be eligible for any government loan guarantee programs.

The company recognizes their success was not, and is not, tied to government sponsored R & D. The obvious difference in success in the two divisions has underscored this point. To a large extent, the difference in the two divisions is one of degree: the one has relied on R & D contracts, and the other has developed products but is still largely selling in a market that is directly government sponsored, or directly created by government action.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1968	$ 23,000	100	4
1979	$2,000,000	65	62

GOVERNMENT INVOLVEMENT

The company found initial success in gaining government R & D funding in three or four agencies, and has not attempted to gain funds from any other agencies or sources.

The company was founded on the basis of government sponsored R & D, and within three years had found the short comings of this total dependence. The company also provides an opportunity to visualize the advantages of a product oriented company over one relying solely on research.

It is apparent from this case study, the diversification offered by product development has many advantages to a small company, even when the product market is indirectly government supported. One of the more subtle issues in this case related to the company's difficulty in developing a market for its products. This problem may be directly related to the company's very limited experience in marketing its R & D capability; i.e., they have not attempted to develop new sources for R & D contracts after their initial success. The parallel in the product area is the introduction of their initial product in 1974, and the five year lag until 1979, when they began to sell into the automotive OEM market. In short, it is difficult to assign a reason to their business problems (research or commercial) without first looking at their possible difficiencies in marketing their technologies to either the public or private sector.

SIGNIFICANT EVENTS AND KEY FACTORS

The company would not be in business today without the original government sponsored R & D contract. However, the dependence proved to be a double-edged sword, and almost caused the company to go out of business four years after its founding.

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1970 by three faculty members and a research associate of a major university, who had done extensive research on the application of electronic technology to the communications problems of the deaf, blind and non-oral. During the 1969-70 period, it had become apparent that some of the research at the university was rapidly approaching a product stage. Since production of these devices was deemed inappropriate for the university, the founders set up their own company. They received funding from two private investors and the university.

Operations did not begin until the following year (1971), when the company received a procurement contract from a government agency for fifty of the units developed in the university research labs. The contract included allowances for tooling and start-up costs. At this point, the company hired 10 to 15 employees, using their initial funding to cover cash flow. The company has been profitable since that time.

In the early days, the company relied heavily on the university's continuing research for new products. As time has passed, there have been changes. Since then, the company has established some in-house R & D capabilities as well as research relationships with many other universities. The development of this information stream has been greatly facilitated by the founders credibility in the academic community, and the relatively narrow focus of their attention on communication aids for the handicapped. The management decision to focus on this area has developed a full network of contributors in the academic community who, in turn, fully understand the company's objectives.

FINANCIAL HISTORY

The company's initial funding of $75,000 came equally from two private investors and the university, in exchange for stock.

In 1975, the company sold an additional $150,000 in stock to attain some liquidity for the initial investors. This is the only other equity money in the company. With this small equity base, it is not surprising the company has developed the management posture of requiring outside financing of its R & D efforts, but does consider them a direct reimburseable expense. To some extent, the company has received R & D funds from private foundations but more typically they are government sponsored.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1972	$ 898,000	100	0	32
1973	$1,308,000	100	0	47
1979	$8,324,000	60	5	200

GOVERNMENT INVOLVEMENT

This company would not have been started, nor would it continue to operate without government involvement. The initial research was sponsored to a large degree either directly or indirectly by government grants. Current research is largely government funded; and the products are sold in government supported markets.

The products being developed and sold are targeted at the nation's handicapped citizens. It is difficult to imagine this much research and development taking place without government support. While a number of the developments have some commercial application, this type of an organization, focused on the needs of the handicapped, would not have taken place without government support.

On the other hand, the company takes a very strong position with regard to return on equity, and as a result has managed to prosper even with the ups and downs of government funding and a very limited specialized market.

SIGNIFICANT EVENTS AND KEY FACTORS

The company views itself as being better qualified to evaluate the technical issues associated with the introduction of a product than a pure research oriented operation. This would appear to be a very sound decision since they have managed to tie themselves into the research operations of the greater U. S. academic community.

The company would not have been formed nor would it continue to operate without government sponsored research and marketplace financing. The company has been able to maintain a relatively narrow focus. This has been possible due to the early market definition and interest.

The company has patent protection on a number of its products, and feels without that protection, they would not be able to survive in their narrow market area. The company has had little difficulty maintaining its patents, and has greatly benefited by licensing and other arrangements with other firms in related businesses.

The company has had a relatively steady growth rate of 20 percent per year. 1979 sales were at the $8 million level.

CASE #3

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1969 by a successful venture capitalist, who saw great commercial potential in a systematic application of existing technologies to the treatment of waste water.

The first action of the new firm was to buy a division of a major U.S. firm. This company made process equipment for the continuous operations of various industries--pulp, paper and mining. The company started in the product business and continues to be in that business today. This business has formed the basis for the company's operations in waste water treatment. Whenever possible, the solution to waste water treatment is incorporated in the use of the firm's process equipment, and in many cases is included in the process itself.

At the present time, it is estimated 75 percent of the company's divisions carry on some form of R & D with less than 10 percent of this effort financed through government grants. The company only has ten or fifteen contracts directly with the federal government, and these have been mostly in the mining field. On the other hand, the majority of the company's business is directly related to federal policy and to a large extent financed by federal grants. The company has also begun to sell their operational experience on a "turn key" basis.

FINANCIAL HISTORY

The founder had three other successful enterprises and therefore did not face the normal financing problems associated with business start-ups. The founder raised $37 million to start the new venture. Of the initial investment, $4 million was contributed by an aerospace firm that had been involved with waste water problems for some time.

In addition to the early financial support, the aerospace firm provided information and licensing agreements plus the use of their science center at a cost plus very nominal fee. While the use of the facilities and the technology exchange were obviously advantageous to the new firm, no commercial products have been developed from this union.

Following the initial round of funding, the company had one additional offering in 1971 during which they sold four million shares at $32 each. In general, the company relies on short-term financing to cover its operating costs. Short term borrowing will run from $0 to $100 million in any given period.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1969	$ 30,000,000	0	100	500
1974	$200,000,000	0	95	3000
1977	$500,000,000	0	90	7000
1979	$800,000,000	0	90	9000

GOVERNMENT INVOLVEMENT

The company views the governmental contract business as an art. Major contractors know how to bid such contracts; i.e., this is their business and they do not make foolish bids. In the waste water business, the municipal governments select the lowest bidder, often ignoring or not making any allowances for the normal safeguards associated with contractor pre-qualifications. As a result, responsible contractors are often put in the position of dealing with other contractors who are literally not qualified to do the work. The result is a project that doesn't perform. The result of this failure is often a law suit against the responsible contractors; the others having gone out of business. This situation also exists in the operation of facilities after they are completed. As a result, the firm is withdrawing from this type of business.

The company feels to a large degree the R & D work they have performed for the government has not been effective. The work has advanced the state of knowledge in specific areas, but the impact has been relatively small because the research was not aimed at real world problems. They specifically mentioned the money and time spent on activated carbon as a filtering agent, and yet not one plant operating in the U.S. is using the process.

SIGNIFICANT EVENTS AND KEY FACTORS

The two key factors in the company's success have been its ability to raise significant amounts of venture capital and the initial concept of using existing technology to build a systematic problem-solving approach.

While the company was, and is, oriented to providing a service that is mandated by government policy, the company has also come to recognize the profit potential in governmental business is very small, and has ceased to provide some services in the municipal sector.

The company also recognizes the need for continuing research. Not only do they encourage this type of activity in their divisions, but they actively recruit to improve technology. In specific cases, the company has made acquisitions to achieve a position based on an improved technology, or more complete product line.

The company also recognizes and is apparently willing to fund research and product development even though they admit it takes on average three years from the idea stage to the product entering market. In mining products, this cycle is eighteen months.

CASE #4

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1965 by scientists from a university cyclotron lab, who perceived a need for cyclotron units far smaller than those currently being built. These scientists had identified several medical and industrial uses for smaller cyclotrons, which they felt the country's major nuclear research organizations had completely ignored in their pursuit of ever larger cyclotrons.

Unfortunately for the company, the market they had originally envisioned never materialized. As a result, the company struggled alone, writing off the accumulated deficit in 1972 (reducing the book value of the company). This process was repeated in 1976 with one major difference, the company had made a profit from its operations for the first time in 1975. With the refinement of its technology, enhanced by acquisition of a subsidiary producing neutron tubes, and the broadening of its markets, the company has shown steady growth in sales and employment since 1976.

FINANCIAL HISTORY

The company's original financing was $1 million raised in a public stock offering the founders made through a public brokerage house. During the company's first ten years, the company's additional financing consisted of an issue of subordinated notes which were later converted into stock and a private placement of $200,000 in stock.

The company has also employed some debt financing including a $1 million loan for product development from the Bank of America.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1965	0	0		4
1975	$1,900,000	0	40	50
1979	$7,000,000	0	20	160

GOVERNMENT INVOLVEMENT

The company has received no direct federal aid. Much of the company's technology, however, was developed under government sponsorship, when the founders were working at the university cyclotron lab. Further, the company's products are sold in markets that, both in the U.S. and abroad, are largely government supported.

SIGNIFICANT EVENTS AND KEY FACTORS

The two key factors in the company's history are its original failure to perform market research, and the development of its overseas market. The company perceived a need for smaller cyclotrons, and began manufacturing before a real market had been identified and developed. Because the company was grounded in an idea, rather than sound business practice, there was a two year lag time before delivery of its first product, and the company spent several years in a severe deficit position.

In the late 1960's, the company began to pursue an overseas market. By 1970, 23 percent of its sales were exports. Since then, exports have accounted for 60 to 94 percent of the company's total sales.

CASE #5

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

This company, a computer based engineering services firm, was formed in 1968. The founders were all employees of a major research organization, and had recognized the need to translate current engineering data into a form consistent with modern computer technology. At this point in time, it had become apparent to the founders that digital technology was, and would continue to be, far superior to the more convenient analog technology then being used by the engineering community. The company as it was originally formed was based on the conversion of engineering problems so as to be soluble on digitally based computers.

The three founders, one an analytical engineer, one a Ph.D. electrical engineer, and the last, a mathematical analyst, convinced a locally based accounting firm to sponsor their initial activities. As a result, an agreement was reached in which their activities would form a new management services division of the accounting firm. From the very beginning, the accounting firm understood that if the venture was successful, the three individuals would eventually leave to form their own company. The concept and the service were immediately successful. As a result, within one year, the three founders had incorporated and established their own business

FINANCIAL HISTORY

In setting up their own business, the partners took the ongoing part of the previous management services operations, and in return gave the accounting firm a note for $240,000. In addition, they sold $50,000 in stock on a private basis and distributed a limited number of shares as founders fees, etc.

Due to the profitable nature of the company's operations, the founders have not been in the position of having to sell additional equity interests. In 1978, the company did establish an Employee Stock Ownership Trust. In doing this, the company did benefit in the amount of $320,000 through the repurchase of some of the original shares at less than their 1978 value and through the sale of some treasury shares. The company has relied heavily on bank borrowing to finance its cash flow needs. This debt financing has caused some problems in its relationship with government agencies and will be discussed later.

The company's current business is divided into roughly three parts: 40 percent state and federal government, 40 percent industry and 20 percent international. The international business is largely supported through AID monies.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1968	$ 900,000	60	*	20
1973	$ 4,000,000	55		130
1975	$ 9,000,000	50		210
1979	$20,000,000	42	*	400

*Impossible to estimate indirect government sales, but the amount would be significant.

GOVERNMENT INVOLVEMENT

The company relies heavily on direct and indirect governmental support for its activities. This relationship has not been without its difficulties. This company is in a business that does not have patent protection, and the application of copyright protection is not effective. As a result, they rely largely on trade secrets and licensing agreements.

The company also recognizes in their relationship with the government, the sale or licensing of a governmental agency to use their software does not preclude that agency from sharing the technology with other agencies under the inter-governmental services act.

The company will quickly point out the inconsistancies in dealing with the Federal government. As an example, the DOD allows bid preparation costs, the DOE does not. Under most governmental contracts, interest costs on borrowed money are not an allowable expense. The theory being payment is received so promptly, there is no need for borrowing. To this, the company points out numerous delays, specifically one experience in which they waited for payment and when it was finally ready for the government to print the check, the government computer broke down. There was an additional three month delay in printing the check. In the company's opinion, the only segment of government that does pay promptly and has consistantly done so is the DOD. On the other hand, they feel the EPA is so bad, they will no longer do business with them. To further round out and qualify this problem, the company points out that the maximum permissable profit they are able to negotiate on a government contract is 8 percent. If you subtract 2 percent for bid preparation and 2 percent for the cost of money, and if there are no problems and you do receive payment promptly, you might make 4 percent on the contract.

Another problem sighted by the company has to do with internal government communications. This company is in the service business. As a result, their orientation is to help the customer. On several occasions, they have encountered situations where the original contract was not adequate to solve the assigned problem. In working with the governmental customer, it has been decided to do some additional work,

work the company points out was necessary to successfully complete the assignment. On several occasions, they have found the procurement section of the same agency will not allow reimbursement for this additional work because it was not specified in the initial contract.

The company has also been critical of state and municipal practices of relying heavily on the lowest bid concept in awarding contracts. While the company recognizes the political and other problems associated with other contracting practices, they point out many state and municipal units of government are not qualified to evaluate bidders, or do not pay enough attention to pre-qualifying bidders. The company feels the current practice of this policy will, in many cases, guarantee the state or municipal agency will not receive the best product, and will in the end, cost the taxpayer more money.

SIGNIFICANT EVENTS AND KEY FACTORS

The most important factor in the company's success was the recognition of the initial opportunity. The recognition came about largely because the three founders were working together in an environment that promoted original thinking and, in fact, created the opportunity.

The second key factor was the accounting firm's sponsorship of the company's early operations. While subsequent history indicates the efforts might have been successful without the assistance of the accounting firm, it is not clear that founders would have been willing to take the risk without the security of the accounting firm's support.

Another factor in the company's development was the founders' ability to obtain debt financing to cover their cash flow between the time they sold a contract and the time they received payment for the service. It should be remembered the formative years for this company was not a period of prosperity in the engineering business.

A final factor in the company's success is the maintenance of close ties with the academic and industrial communities. In order to keep up with the rapidly changing technology in this field the company relies on its own staff capability, and staying close to the various professional societies and industry publications. When they encounter an area in which they feel the need for assistance, they rely on consultants. As a general rule, the consultants they hire are from a local nationally known university, generally faculty members. By providing these opportunities to the faculty, they have managed to gain considerable insights into the capabilities of the graduating students. This university happens to be the primary source for the company's young employees.

CASE #6

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1967 by an engineer (Founder 1) whose principal interest was in the area of glass to metal seals, and a businessman (Founder 2). They decided to strike out on their own when their previous employer exhibited little interest in the flash lamp business. Shortly after the founding of the company, they were joined by two other men whose primary interests were in ceramic to metal seal technology. These four men had foreseen the need for a company to produce a specialty lamp for a variety of uses. The other firms in the lamp business did not feel this market was a large enough one to justify their interests.

The initial sale of this technology was in OEM sales to the Xerox company for use in their copy machines. After this sale, the company concentrated on sales in the OEM market. This concentration and the prosperity associated with the Xerox contract came to a sudden end in 1970 during the general business downturn. This downturn came at a particularly bad time for this company. When the downturn came with its associated contract cancellations, the company was forced to lay off a large portion of its work force and salaried people were put on half pay. With the business rapidly deteriorating, the company's banker helped them secure an SBA guaranteed loan. During this period, the founders were forced to pledge all of their personal property as security on the existing loans. Fortunately, the business began to pick up shortly after this period, and the SBA financing was replaced with conventional financing. Employees who had been on half pay were offered the opportunity to take their back pay in stock or cash, and the company was back on its feet. It should be noted that this offer of stock in lieu of pay was the last dilution of the company's ownership.

The company's current business is approximately 25 percent government contract, 10 percent indirect government contract procurement, and the rest is to the OEM market. The company has, at various times, been the recipient of government R & D contracts, but these contracts have never resulted in a product. In some cases, they have developed an idea to the point of developing detailed manufacturing manuals for the production of a product, but have gone no further.

The company does not consider patents important in this business. They rely on their engineering and marketing ability to remain profitable. Even though the company could be classified as a small business, they have no knowledge of experience with the so-called small business set-asides. They compete directly with major companies in the field.

Technology is generally introduced in this company through their field engineers. The interaction of the company's field engineers and application engineers with their customers is considered to be the prime source of technology.

FINANCIAL HISTORY

The company's original financing was $300,000 of private venture capital. In 1969, they received an additional $200,000 in private venture capital to increase the size of their plant and to buy equipment.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	$ DIRECT GOVERNMENT	$ INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1967				8
1970	$1,000,000	35	10	26
1979	$8,000,000	30	10	190

GOVERNMENT INVOLVEMENT

Perhaps the most important point of government involvement came when the company received an SBA guaranteed loan that allowed them to continue operations. With all of the demands placed on the founders for collateral during this period, there is no question the government guarantee had an effect on their ability to obtain additional debt financing.

This company, as were others that were interviewed, has experienced financial problems as a result of the delays in receiving final payment on governmental contracts. The 15 percent set aside provision has been particularly difficult for this company. The company cites numerous contracts that have been completed, but not closed out due to delays in auditing, some for as much as eighteen months. The company feels that allowable margins on government contracts do not provide adequate financial rewards to cover the delays associated with receiving the final 15 percent payment.

SIGNIFICANT EVENTS AND KEY FACTORS

There are three significant factors in this company's history. The first was the decision by the founders that there really was a market for a specialty lamp manufacturer and their ability to attract the necessary venture capital.

The second major factor was the dissolution of their original market. The final and major factor was the ability of the company founders to pick the company up from a disasterous crash and put it back on its feet.

CASE #7

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

This company was organized by two individuals doing advanced optical research work for a major U.S. electronics firm.

One of the individuals learned of the need for an optical quality control device in the grading, and quality control of tree fruits in the California canning industry. At the time this grading and quality control function was being done manually and visually by college students employed for the canning season. The manual grading of tree fruits had all of the inconsistencies of any process involving human efforts, but also had a deeper problem in that the farmers were paid for their crops on the basis of this grading. Obviously, if the farmer did not get top dollar then he would complain about the grading.

With this problem in mind, the two founders organized a company in 1967 with $150,000 in venture capital collected from relatives and friends. The purpose of the company was to develop an optical and mechanical grading system for tree fruits. The initial target was to be the cling peach canning process. The partners did develop a product to perform these functions. Unfortunately, the cyclamate ban hit the canning industry about the same time the product was introduced. The cyclamate ban had a devastating financial impact on the canning industry, and the canning industry became much more concerned with financial survival than new technological innovation.

Following the collapse of their original market, the two founders continued R & D on their product. In 1970, it became necessary for the two founders to find additional funding. After a long search, the partners found a midwest venture capital firm willing to invest $500,000. One of the conditions of the agreement was a revision of the company's management. The venture capital firm hired a west coast management consultant to act as chairman of the board of directors. After his initial review of the founders activities, the new chairman of the board fired one of the original partners who had been acting as president of the company. This founder left the company and went off to start his own non-competing electronics firm. The remaining partner was made a vice president and placed in charge of the product development. A new president was brought in to take charge of the company.

In early 1971, the company introduced a new product based on their original efforts. This product incorporated other existing technologies to produce a far superior product to anything then on the market. In simple terms, the product measured the light refraction from a particle suspended in liquid. While most competing products could perform this task, they measured the light refraction at right angles to the particle. This company developed a process to measure this light refraction as it was projected in front of the particle. This process allowed measurement of solids suspended in liquids, with obvious implications in waste water treatment. The company's product has met with success in the industrial sector. Following the introduction of this product, the company continued to refine its technology and now has twelve products based on their original concept.

In addition, the company has made a number of acquisitions, both of small companies with useful technologies, and of specific technology from larger companies. These acquisitions should lead to greater product diversity and thus widen markets.

FINANCIAL HISTORY

The company's first round of financing was the $150,000 in venture capital the founders raised from friends and relatives. This financing supported their development of a quality control device for the canning industry. When the ban on cyclamates decimated this market, the original funding was sufficient to support continued product development. In 1970, however, the founders had to seek additional financing. They secured $500,000 from a midwest venture capital firm. The terms of the agreement included equity in the company, and considerable control over the company's management.

Since the initial venture capital investments, the company has operated on debt financing through the commercial banks, with guarantees by the midwest venture capital company. The company has always been in a cash poor position, and anticipates the new high interest rates will create many new problems for the company. Even with the continuing cash shortage, the company has actively attempted to increase its product line, both internally and through acquisitions. In 1973, the company acquired a small, struggling company that made pH instruments. This acquisition was accomplished with a little cash, some stock, and a performance contract with the owner. In 1977, the company had the opportunity to acquire a product line from a major manufacturer. This acquisition for a product line of self-cleaning instruments was accomplished with cash borrowed from the bank. The company is still paying on this bank loan. In 1978, another company was acquired to obtain rights to their product line of probe-type magnetic flow meters. This last purchase was for some cash, some stock, and a royalty agreement.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	$ DIRECT GOVERNMENT	$ INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1972	$ 0	0	0	2
1980	$5,000,000	5	5	60

GOVERNMENT INVOLVEMENT

The most important relationship this company has had with the federal government has been extremely negative. When the company introduced their new product to measure the size of suspended particles, the EPA regulations called for a specific instrument to measure particle size. This specific instrument was even called out by manufacturer and model number. The company attempted to convince the EPA of the merits of their product, to no avail. It was only over the course of time that the company was able to organize enough companies in the particle measurement business to convince the federal agency to change the specifications to the extent that the term "or equivalent" was added. Even this modification did not allow for any measurement other than right angle measurement, even though the forward measurement is recognized to be superior in industry. In order to meet the federal agency specifications, as modified, the company had to go back and develop a right angle measuring device, which the company claims is not as good as their original device.

This experience, as described above has been a continuing source of irritation to the company and has been going on for over eight years. To further the controversy, the company now feels the manufacturer called out in the specifications is infringing on its patent rights with a new product it is currently introducing.

SIGNIFICANT EVENTS AND KEY FACTORS

Two major factors shaped this company's history, the collapse of its original market and the terms of its second round of financing.

The founders had originally developed a quality control device for the canning industry. Shortly after they brought the device to market, the market collapsed, thereby forcing the founders to apply their technology to the development of another product for another market. Their new product

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had many more applications than their original product, and thus broader markets. The company now has many different products.

The second factor in the company's development was the restructuring of its management as a condition of its second round of funding. A major problem with many high technology firms is that founders who are good technologists but poor managers often retain control over the company, to the company's financial detriment. Although the restructuring was not pleasant for the founders, it put the company on sure business and management footing.

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

This company was founded in 1972 by an engineer from a large research laboratory who sought to develop the first commercial application of liquid crystal fluorescence, a scientific curiosity that had been discovered nearly eighty years before. Initial sales were exclusively to the consumer products market and were of a fad nature. The product met with a great deal of success in its early years with sales reaching $2.9 million in its second year of existence. However, since barriers to entry into this market were small, and the original patent had not been issued, several small companies entered the field and price cutting began. The impact of this condition can be seen in the following comparison: By the end of 1974, the company had achieved sales of $3 million with a pre-tax profit of $850,000; the following year, sales also reached the $3 million level, but the company lost $850,000. As a result of this situation, the company went into Chapter 11 reorganization in late 1975.

The company made an unusually rapid recovery from its Chapter 11 status as a result of several key moves made before reorganization. Even as prices were falling, and the parent company was losing control of its own manufacturing costs, the company had acquired certain assets and product lines from another company in a similar business.. By far the greatest of these assets was the president of the other company, who had been one of the leading scientists in technological innovation in this field. This gentlemen assumed control of product development for the merged companies. Within two years, the company had improved its technology and had introduced products superior to anything then on the market. In addition, it had filed for and been granted fourteen U.S. patents and a number of parallel foreign patents.

Because of this basic technological strength, the company was able to come out of Chapter 11 within six months (January, 1976) with new management. During 1976, the company did extensive work to commercialize its many new technological developments, rejuvenate dormant markets, and improve the efficiency of its manufacturing operations. During this period, even though the company was chronically short of cash, it invested heavily in capital equipment. In July of 1976, it also formed a joint venture with its European distributor to market the company's products in Europe, the Middle East and Africa. Many of its products are now manufactured in Europe using OEM components supplied by the parent.

The company had earlier determined to concentrate its efforts into three major areas; OEM supplies, medical products, commercial products for advertising and finished products for mass merchandising. In order to follow this line for their products, the company actively began to seek acquisitions that would help in achieving the desired results. By July of 1977, the company had successfully completed the merger of their company with two other companies. The resulting entity (with a new name) provided the necessary breadth of product line and technology to successfully compete in the desired markets.

Initially, each of the three subsidiaries continued to operate in its field of strength and their combined operations were attractive enough to bring in additional venture capital. However, by 1979 it was clear a consolidation was necessary and a new site in California was chosen for the combined operations.

At the present time, the company's sales in the U.S. amount to $2 million, with an additional non-consolidated $1 million from their European operations. These sales are split roughty in thirds between OEM, medical and consumer sales.

FINANCIAL HISTORY

The company's initial financing was $10,000 the founder raised to set up manufacturing of the company's original commercial product. During the company's period of rapid growth, the founder raised an additional $40,000 from venture capital. In 1976, one of these investors supplied $50,000 to the company during its Chapter 11 reorganization, which both hastened the reorganization process and kept the company afloat.

In 1977, the reorganized company brought in $50,000 of working capital through the sale of preferred stock to an SBIC. These funds enabled the company to make the necessary acquisitions and developments to establish its three major product lines, which between 1977 and 1979 brought in another $320,000 in venture capital.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	$ DIRECT GOVERNMENT	$ INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1972	0	0	0	1
1974	$3,000,000	0	0	75
1979	$3,000,000	0	15	60

GOVERNMENT INVOLVEMENT

The company's involvement with the government has been varied. The government has been an indirect source of technology and financing. It has also been a source of tremendous consternation with regard to new product regulations.

The founder of this company was previously employed in a research capacity in a research organization that does a significant amount of governmental research. There is nothing that would indicate the product manufactured by the company had anything directly to do with the government.

sponsored research. However, the research environment certainly contributed to the founder's ability to develop the product.

At a critical time in the company's development, it was able to secure additional capital through the sale of stock to an SBIC. Although other sources of capital were abaliable to the company, the SBIC offered the best terms.

In the medical area, the company deals with the Food and Drug Administration and has found the FDA regulations for the introduction of products particularly onerous. It feels the FDA unnecessarily restricts the entry of new technology and innovation in the medical field. These restrictions place an additional financial burden on the small manufacturer, and increase the cost of medical products to the consumer once they have been introduced.

SIGNIFICANT EVENTS AND KEY FACTORS

From its inception, this company has been characterized by extremes. The initial commercial application for a relatively well known scientific curiosity was an unqualified success. The company's failure to gain patent protection, failure to control their manufacturing costs, and initial refusal to sell to the OEM market just about finished off the company after two years of operation. On the other hand, in the face of adversity, the company turned back to their basic technology and developed improved products, with protection. This re-orientation attracted the additional capital needed to keep the company in operation. The company also developed a basic marketing strategy that diversified their product line enough to enter three distinct product areas; the original consumer market, the new medical market, and the previously shunned OEM market. In order to put this market strategy into operation, the company merged with two other companies. The initial merger was not totally successful because the merged companies failed to realize the humidity in the midwest would have an adverse affect on their manufacturing process. The eventual recognition of this difficulty has resulted in a consolidated, profitable company relocated in California.

CASE #9

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

In 1963, this company was formed by a foreign national to supply products to the space program. After some moderate success, the space program was downgraded in 1967, and the firm was in serious financial difficulty. Unfortunately, there were some other problems relating to the founder and his management of the company. As a result, the founder left the country. In 1968, a new president was appointed and the company began to enter some new fields. In 1969, the company merged with another cash short firm that had a product in the emerging telecommunications field. This proved to be a growing field and the company began to prosper once again. During this period, they were able to attract additional operating capital by privately placing convertible issues of stock.

By late 1971, the company, convinced of the growth potential in the computer industry, made a decision to enter the computer main frame business. The basic decision was to use the profits from their operations in the telecommunications business to finance this new venture. Eventually, the company intended to bring the new computer product to the point that would support a public offering to raise the funds necessary for a long term program.

This program failed for a number of reasons. The 1972-73 recession that hit the electronics business found this company desperately short of cash. The company management had geared up for a crash effort to enter the computer business and when sales dropped in the telecommunications business, there was no way to avoid Chapter 11 proceedings, which they entered in early 1974.

By October of 1975, the company was out of Chapter 11 with a new management. The company dropped all plans for the computer business and has concentrated on the telecommunications business, with one new product line added (also in the telecommunications business) in the last five years.

The company has been profitable since 1975.

FINANCIAL HISTORY

The company's original financing was $200,000 in private capital raised by the founder. After the company's merger with a telecommunications firm in 1969, it raised working capital through a private stock offering.

In 1971, the company decided to move into the computer field. It financed its initial forays with profits from its telecommunications work. Unfortunately, by 1974, this new venture forced the company into Chapter 11 reorganization. No information is available on company financing since reorganization in 1975.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	$ DIRECT GOVERNMENT	$ INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1967	$ 500,000	100	0	60
1970	$ 700,000	0	10	65
1972	$ 750,000	0	15	95
1973	$ 500,000	0	15	95
1976	$ 800,000	5	10	35
1979	$3,500,000	0	15	55

GOVERNMENT INVOLVEMENT

The company was originally involved in the space program, and like many companies in the electronic business, experienced the boom or bust nature of government sponsored programs. Their experience in the component business has been quite different. The company has had a contract with GSA to supply telecommunications products to government installations. After one year, the company elected not to renew the contract due to the excessive cost of the paper involved in the contract. As an alternative, they took their mil-spec products and put them in their general product catalog. According to the company, the GSA has continued to buy their product at approximately the same rate, and the company has increased its profit margin per sale by avoiding the paperwork associated with the previous contract.

SIGNIFICANT EVENTS AND KEY FACTORS

This company has been primarily oriented to filling a perceived need in a market rather than developing a market. Their initial product was designed to fit into a need in the space program. The company did not take adequate precautions to protect its assets, or to position itself in another market in case the space program folded. The cycle was repeated in the telecommunications field, and the computer business. The problems with the computer business were compounded by the high risk nature of its entry into a market where they knew they had an inadequate financial base. In the end, the company went back to its basic bread and butter product and have prospered.

CASE #10

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The initial work and concept relating to the primary product of this company was started in 1964 by a doctor at one of the major local hospitals. The intent was to develop a low cost lens to assist in the correction of eye defects in children. By 1969, five years later, the doctor had developed the lenses and formed a company. The formation of the company was financed by a limited stock offering of $1.7 million.

As was indicated earlier, the doctor had developed his product prior to forming the company. The product he developed was intended to replace the wedge shaped prisms being used to correct eye defects (crossed eyes, etc.) with low cost paste-on Fresnel lenses. To accomplish this objective, the doctor took the initial investment and hired fifteen full-time salesmen to cover the eye care market in the U.S. While there was some initial interest exhibited by distributors, the basic response was not positive. Eye care doctors did not want to be in the business of pasting on lenses, and the people in the business of preparing lenses did not want to do the work, because they did not feel it was professional. There was a strong suspicion the profit margins were also too low. In short, after expending approximately $600,000, it became apparent that this was not going to be a successful marketing campaign, regardless of the merits of the product.

The first three years of company operation were at a loss. Then just as things looked darkest, a contact was made with a major manufacturer of instant cameras that resulted in a major contract for the company. The company became the sole source supplier for one of the most popular instant cameras sold in the U.S., and remains in that position today. By 1974, the company had sales of $2 million, of which 65 percent were lenses for the instant camera. At that point, the company producing the instant camera made a discovery. They had made a gross error in their estimation of their need for lenses. As a result, they had an eighteen month supply on hand. 1975 was a year in which the company received no orders for camera lenses, but still managed to make a profit. In 1976, the company hired a new management team and the company began to take on new dimensions.

Under the new management, the company has divided its business along three basic lines. The company and the founder are still in the R & D medical business, attempting to develop ophthalmic instruments. They have developed a strong sub-contractor position in the solar field, and their proprietary lines represent a variety of products from big screen television to a variety of lenses for the auto and direct consumer markets.

FINANCIAL HISTORY

The company raised $1.7 million at the time of its founding through a limited stock offering that was handled by a well known brokerage firm. Almost $600,000 was spent in the unsuccessful attempt to enter the eye lens market and the first years of operation were at a loss. When the camera lens application was discovered, however, the picture improved drastically. In recent years, after a new management team was hired in 1976, the company experienced only one of operation without making a profit. Aside from the initial stock offering, the company has operated almost entirely on retained earnings. The current debt structure of approximately $200,000 is covered by lease arrangements for capital equipment.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	$ DIRECT GOVERNMENT	$ INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1969	0	0	0	15
1974	$2,000,000	0	20	40
1979	$3,000,000	0	35	57

GOVERNMENT INVOLVEMENT

This company does business with the government both in the medical R & D business, and also as a subcontractor in the solar business. Their experience in the medical R & D business has been relatively positive, and they hope to develop three new ophthalmic instruments based on their research.

In the solar business, they are experiencing some difficulty in coping with the delays in receiving payments due in the 15 percent set aside requirements. This company is literally at the crossroads of breaking into some major new areas, or remaining small and vulnerable. They have managed to get this far because they have been very careful (after their initial experience). The business is basically a capital intensive one in which they have carefully recruited the technology they need for success. They are currently being hurt by the time it takes to collect, in one case for over a year, from the government. Yet they see a great potential in the solar business. Additional governmental regulation could have an adverse effect on their operations.

SIGNIFICANT EVENTS AND KEY FACTORS

Obviously, one of the most significant events in the company's history was the initial sales attempt for their paste-on lenses. Although the users of the corrective lenses could be clearly identified, the attitudes of people who controlled access to the market were not understood. This is a typical case of believing if the technology works, the product will automatically be successful. This failure must have had a tremendous psychological impact on the company's founder. Especially since he had spent many years perfecting the technology even before the business started.

The other major experience has been associated with the initial contract to produce lenses for the instant camera, and then the discovery that there would be no more orders for an extended period of time, due to an oversupply. Throughout all of these events, the underlying strength of the company and its strong initial financial backing has allowed the company to remain in business. The company is currently financially sound and operating in a profitable and conservative manner.

CASE #11

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

In 1953, a large U.S. conglomerate bought a majority interest in a small company manufacturing simulation devices for guidance equipment. The small company continued to operate independently for five more years. During this period, a new president was appointed. In 1958, the company was brought into the conglomerate's corporate structure. The former president became the Division Manager. As time passed, several difficulties became evident. First, the division was so small, it was virtually lost in the corporate structure. Second, the division was profitable and could take care of its operating needs but being such a small part of the operation, the division was unable to get funds allocated for new product research and development. This situation continued for three years.

In 1961, the former President and Division Manager raised $300,000 through a public offering to 250 individuals and started a new business. The new business, in effect, introduced the second generation of the product being marketed by the conglomerate; what he had spent three years trying to get the conglomerate to do. The new company received its first order three months after it opened its doors for business. While the company did not make a profit in its first year of operation, by the end of the second year, the company's products had forced the conglomerate's competing products from the marketplace. The new company then purchased, at a very reasonable price, the tooling and drawings for the products the conglomerate was withdrawing from the market. The company viewed this move as a goodwill gesture to the conglomerate's former customers who would need service for their existing equipment. It is to be presumed these same customers would be buying new equipment at some later date.

FINANCIAL HISTORY

The initial financing of $300,000 came through a public offering to 250 individuals. Since then, the company's growth has been financed almost totally through retained earnings. There have not been any additional equity offerings, and peak cash flow requirements have been financed through short-term loans.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1961	$ 70,000	85	15	8
1974	$1,500,000	60	5	35
1979	$2,500,000	50	10	50

GOVERNMENT INVOLVEMENT

An important episode in the company's history occurred during the problems associated with the C5A contract. Basically, the prime contractor had seriously underpriced the final product. The effect of this underpricing had a ripple effect on the sub-contractors. In this case, the company lost $300,000 on their part of the contract. Evenutally, a process was established for the contractors associated with the C5A to recover their losses. This company complied with the requirements, filed the necessary supporting documents, and submitted their claim. Unfortunately, they were the first contractor to file a claim. In the view of the founder, this was the reason the claim was turned down. The people reviewing their claim knew there would be a number of contractors filing claims, including the prime contractor, and they did not want to set any precedents over $300,000. Fortunately for the company, they had other profitable contracts at the time, and this was a major annoyance rather than a catastrophy. They still remember the case with considerable ill feelings toward the government auditors, however.

This is a company that does business with the government, knows their business and understands their customer. They are thoroughly familiar with the process under which they live and prosper under conditions that cause difficulty for others. While they have occassionally been bothered by the 15 percent set aside provisions coupled with slow audits, or a difficult procurement officer, they are not hesitant to call whomever could help, if they feel payment is being unnecessarily delayed. They are also quick to point out properly processed progress payments are paid by the DOD as fast or faster than many of their commercial customers. The company knows and understands the advantages they have as a small business and takes full advantage of their position.

SIGNIFICANT EVENTS AND KEY FACTORS

The impetus for founding this company was clearly the inability of a large firm to recognize and accommodate the needs of a small, innovative division. The parent company was inhibiting the technological investment in R & D necessary to stay competitive and to keep competent technical staff. Another factor was probably the availability of money through the public market in 1961. It is likely that similar start-up financing for a comparable amount of money today would be very difficult to obtain.

The company's ability to purchase the toolings and drawings from the old parent company probably also had a major positive effect. By providing service to previous customers, the new company gained access to some of the major potential users of their newer equipment.

CASE #12

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

This company was formed on July 1, 1962, by three Ph.D. physicists from a major government sponsored research laboratory and venture capitalist. The initial venture capital was composed of small amounts from each of the physicists, $150,000 in equity capital and approximately $250,000 in loans. The company was formed to take advantage of the technical knowledge gained in the founders' work in nuclear research. The founders felt their knowledge had value in and of itself, but they also had over fifty possible products they felt could be developed utilizing the technology developed in their research.

In order to keep the company on a solid footing, however, the founders immediately started looking for R & D contracts. They did not have long to wait, within three months they had their first R & D contract. By 1963, the end of the first year of operation, the company had sales of $300,000 with 20 employees and was operating profitably.

In the time between 1964 and 1970, sales and profits increased rapidly reaching a level of $18 million in 1970 with over 600 employees. This period also saw a number of efforts at diversification.

In 1967, the company acquired the rights to a very small company that produced a line of electro-optical radiometers and was also developing a programmable desk top calculator. The initial acquisition was really a shell; the ideas were there, but little else. The company eventually put over $5 million into this venture. Initially, the operation was allowed to function independently of the company, but in 1969, the acquisition was brought into the corporate structure as a subsidiary. In 1971, this acquisition was sold to a major U.S. supplier of electronic test equipment.

In 1968, the company entered into an agreement to exchange stock with a minerals exploration company. The objective was to form a jointly owned company that would develop products for the oil well industry, various forms of mineral analysis, and participate in the AEC's Plowshare Program. In 1972, the company acquired all of the rights to the joint venture and the company's stock owned by the former partner was sold on the open market. In 1975, this venture was dissolved.

In 1969, the company acquired a company manufacturing large precision magnets for the high energy particle research. In this case, the company developed the rudementary forms for an ion implantation system. During this period, the company also developed a working relationship with one of the giants in the developing semiconductor field. In the end, the company once again lost interest and the acquisition was sold. In this case, it is interesting to note several of the individuals working on this project left to form their own company when the parent decided to give up the business. These individuals joined others interested in this area of development and are currently doing quite well.

In 1969, the company went public selling 600,000 shares at 8½ per share. The proceeds from this sale were principally used to finance the commercial ventures described above, particularly the desk top calculator. As has been noted previously, the company's sales reached $18 million in 1970, but by 1971, they were down to $14 million, and by 1972, they were down to $9 million. These were difficult times for this company. Its main product, R & D, just was not selling and the company's previous efforts at developing commercial products had not been successful. Nevertheless, the main reason for the big drop in 1972 was the termination of three major research projects, two for the convenience of the government and one due to its completion

The company continued to operate at the $9 million level through 1974 and into early 1975. Once the company went through their initial drop, and took a hard look at their operation, laid off the necessary people and divested themselves of their subsidiaries and wrote down the losses, they found they were in a secure financial position. They were still benefiting from their strong cash position as a result of their stock sale, and in 1973-74, they were able to operate at a profitable level. In fact, once a full evaluation was completed of the 1972 period, they realized the parent R & D company had been profitable, but the subsidiaries had dragged them into the red.

During the period 1973-74-75, the members of the board of directors had been searching for a way to stabilize the company. The board was anxious to find a situation that would give the company a broader based market and strengthen the management. In August, 1975, the company was sold to another research based organization in the Northwest. This merger, which on the surface did not seem to make sense, has been very successful. The company has continued its profitable operations with little interference from the new parent, and both partners appear to be pleased with the resulting organization.

At the present time, the company's sales are divided between direct government (70 percent), indirect government (20 percent), and foreign (10 percent). The company is almost totally in the research and development business with the one proviso that almost half of all of their contracts result in some type of hardware. A major fraction (50-60 percent) of their business involves R & D of pulsed high voltage energy sources.

FINANCIAL HISTORY

The company started in 1962 with a little over $400,000. A small amount came from the technical founders, $150,000 was equity capital, and about $250,000 came from loans. Between 1964 and 1970, sales and profits increased rapidly. In 1969, the company went public, and raised about $5 million. This money was used primarily to finance the various acquisitions and attempts at commercialization. The details can be found in the history section.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1963	$ 300,000	100	20
1964	$ 1,300,000	100	50
1969	$10,200,000	90	600
1970	$18,000,000	95	700
1972	$ 9,000,000	90	300
1975	$ 9,000,000	90	300
1979	$16,000,000	95	400

GOVERNMENT INVOLVEMENT

This is a company that is almost solely involved in government sponsored research. Similar to other companies interviewed, the company indicated the DOD is the agency it prefers to deal with primarily because it appears to have a better understanding of the industrial research environment. The company also deals with DOE, NASA and HEW and did not have any specific negative comments about their business relations with any of them. In fact, there was an amazing correlation between the responses from this company and the one covered by case #11. In both situations, the companies were oriented toward business with government or other government suppliers with few, if any, commercial products.

One additional item of interest was in relationship to the introduction of new technology. This company cited numerous examples of having a new technology turned down by the U.S. government, and being forced to take that technology overseas and successfully introducing the new technology before the U.S. government would develop an interest. This comment appears in other case studies. It was also noted that they have often encountered situations where the government specifications and the tests don't match, or the specifications and the actual use of the product do not match. One comes away with the impression there may be a serious government procurement problem, i.e., maintaining the procedure while forgetting the purpose.

SIGNIFICANT EVENTS AND KEY FACTORS

There are two fundamental issues and three significant events in the company's history. The first issue is the failure of the company to develop any commercial products. The company struggled with this issue from its very beginning and would appear to have given up on the idea at the present time. The second issue is the company's success in finding a place in the pulsed high power energy field. This was one of the technologies the founders brought to the company, and the company has been a leader in extending the state-of-the-art.

The three significant events include: first, the public offering of their stock, followed by a drop in government sponsored research and their ability to cope with this problem. Finally, the sale of the company and their successful relationship with their new parent.

This company has also, indirectly, been running its own economic development program. There are currently five companies operating in the immediate areas that are technological spin-offs of this company. All five are apparently operating at a profit and producing products for the commercial or governmental markets.

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1963 after a patent attorney (Founder 1) suggested to Founder 2 to develop a potentially marketable technology in a patent application he was filing for Founder 2. The applicant (Founder 2), a university professor, had developed a new and promising method (Method A) for separating gases in large diameter columns. Founders 1 and 2 felt that with sufficient investment in research and development, Method A could make a new market then only used for analytical and small scale production. Founder 1 convinced Founder 2 of the advisability of bringing the research out of the university lab and into a private firm.

Founder 1 served as the company's business and legal director on a part-time basis from his law practice. Both founders were responsible for securing the company's initial and subsequent financing rounds. Founder 2 served as technical director, also on a part-time basis from his academic responsibilities.

In 1963, using funds from a private investor, Founder 2 set up a small lab where he and a hand-full of graduate students worked on Method A. The company moved to larger quarters and retained a more permanent staff. In 1967, the company redirected its efforts to a more accessable separation technology (Method B). In that same year, it received a crucial government contract under which the company developed a successful medical device using Method B. The company later licensed this technology into an equally successful industrial device. The company recently divested itself of all government R & D contracts and is pursuing industrial applications of Method B technology.

The company has never gone public. In 1977, it became a wholly owned subsidiary of one of its early investors, but continues to function independently.

The company's original technology came from Founder 2's university research. The company hoped to develop and refine Method A of chemical separation into a commercially marketable product, and devoted four years and a lot of effort and money. In addition, two of the later employees became particularly enthusiastic about a second method (Method B) for separation and the company supported their research as well.

By 1967, it had become clear that Method A's development to product stage would require another 10 years research and considerable additional funding. The company made a decision to discontinue Method A research and expand its work on Method B, which was coming close to commercial applicability. Although the company's intent was to improve Method B technology generally, the company's R & D was soon focused on a very specific application.

A federal agency became interested in one aspect of the technology and awarded the company a $220,000 contract to develop it for use in kidney dialysis devices (see Government Involvement section for details). It took another five years and additional financing to develop the technology. The company then licensed the technology to another company for production and marketing. About the same time, an application was developed for the auto industry and now dominates this market worldwide.

In the meanwhile, the company had developed a biomedical division and merged with another company started by Founder 1 and one of the private investors to form an environmental division where they worked on testing devices. However, in 1979, management decided that in view of the problems with government contract work, they would phase out all such work and concentrate on developing industrial applications of its technology (Method B). The biomedical division has been phased out and the environmental division was sold out to an employee.

FINANCIAL HISTORY

Founders 1 and 2 obtained the company's original financing in 1963 from a private investor industrial firm very much interested in technological innovation and helping small firms get started. The company received $25,000 in materials and services in exchange for 25 percent of its stock. The investor also provided Founder 2 with lab space in the investor's own building. The company used the funds for setting up the lab, product R & D cash flow.

Unfortunately, Founder 2 and the investor did not get along personally and parted company after nine months. In 1964, the company received $108,000 from a very large firm for 25 percent of the company's stock and a member seat on the company's board of directors. The company used $33,000 of these funds to buy back the original investor's stock. The other $75,000 it devoted to setting up a new lab, cash flow and R & D.

In 1967, a second large and different firm paid the company $650,000 for 22 percent of its stock. Later, about 12 percent of the common stock was sold to another and different industrial firm for $400,000. This money was again used for Method B R & D. Also, in 1967, the company received a $220,000 government R & D contract for a specific Method B medical device. After 18 months, when the product seemed viable, the company obtained an additional $900,000 for product development. This financing round had three sources: the federal agency as a government contract; a very large health care products company in exchange for a patent license; and the founders' personal funds as a loan. The outside company became hesitant about the device and its marketability and sold back its interest to the company for less than its investment, since the rest would have been paid in taxes.

With the profits realized from the medical device royalties, as well as its development of industrial applications for Method B technology, the company needed no additional outside financing. In 1977, the company was wholly acquired by its second investor, to obtain complete management control.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1963	0	0	4
1974	$ 3.0 Million (approx.)	70	80
1979	$ 12 Million (approx.)	15	225

GOVERNMENT INVOLVEMENT

The company's direct government involvement did not commence until four years after founding and then under somewhat unusual circumstances. NIH had heard about the company's Method B technology. Another very large chemical firm was developing similar technology and was the only firm in the country applying it to the development of a kidney dialysis device. The federal agency wanted to encourage competition in the field and so asked the company to submit an "unsolicited" proposal to work on this same device.

Although one of the company's board of director members objected to any government involvement, the company had been unable to secure financing for Method B development from any other source. While the company was under contract, the application of Method B (it received a second contract as well) to a particular medical device, it was also able to develop and refine general Method B technology. Thus, government funding was one important factor in the company's later success when it developed more remunerative commercial and industrial applications of Method B.

The company's success under its original government contract facilitated additional awards which for many years supported the work of both its biomedical divisions.

In 1979, however, the company made a corporate decision to curtail all government work. The company's application of separation technology to the automobile industry had been highly successful. The board of directors, which had never felt comfortable with government work, viewed this as a clear indication that true corporate success lay in further industrial ventures rather than government contracts. They were very anxious not only to increase profits above amounts allowed for government P & D, but also to free the company from bureaucratic paperwork and constant writing of proposals to procurement officers.

SIGNIFICANT EVENTS AND KEY FACTORS

The three important factors in the company's success were its decision to abandon development of Method A in favor of Method B; its 1967 government contract for Method B research, and its relationship to Founder 2's university.

By 1967, the company had spend about $2 million on the development of Method A. Its investors were becoming impatient but no immediate end was in sight. The decision to abandon Method A was a wise one. It took another company 15 additional years and considerable investment to finally bring Method A to market. It seems unlikely that the company would have found the requisite financial backing to complete the project. Method B was far closer to the product stage, and the company's timing in its adoption (unwittingly) coincided with market demands.

The company's 1967 NIH contract catalysed the company's success, both financially and technologically. After the company's essential failure to develop Method A, it could find no private backers for Method B development. The $220,000 NIH contract and its renewal propelled not only the development of a specific product, but also the refinement of Method B for other industrial applications. It helped to finance the technology upon which the company is presently based.

The third factor essential to the company's success was its relationship to Founder 2's university. University policy encouraged faculty members to spend one day a week on outside consulting. If Founder 2 had been forced to choose between the company and the university, the company would never have been founded. Instead, he was able to develop commercially a promising technology and fulfill his academic obligations. As noted before, Founder 2's straddling of the university/industry interface also aided in keeping him abreast in the separation field and in providing the company with a renewable source of highly trained technical personnel. At one time, over 10 percent (14) of the university's 10 year output of chemical engineering Ph.D.'s were on the company staff.

CASE #14

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1962 to exploit technology Founder 1 had been developing in his university research. The company's initial goal was to secure research contracts from industry as well as the government. Through these contracts, the founders hoped to put the company on sound financial footing, broaden its technological capabilities, and develop a commercializable product.

In order to retain as much control over its research as possible, and thus its potential products, the company entered into somewhat non-standard research agreements with its industrial sponsors. Rather than enter a contract that granted the sponsor full ownership of the technology in return for payment of research costs, plus a fee, the company sold joint development programs under which the sponsors would cover 60 to 80 percent of the R & D costs in return for a limited royalty-bearing license. In exchange for covering 20 to 40 percent of the R & D costs itself, the company retained ownership of the technology, would receive royalties from the sponsor upon successful commercialization and could commercialize itself applications of the technology not in conflict with the sponsor. The company also negotiated minimum annual royalty payments to help insure a sponsor's diligence in bringing technology to market.

During the course of its research work in the mid 1960's, the company developed unique technology in two different fields. The company established separate divisions to produce and sell each of the two product lines.

The company's first full year's sales of $100,000 were entirely for R & D. Of present sales, which have climed to $20 million, 95 percent represent product sales and only 5 percent R & D. Employment has risen from 8 in 1962 to its present level of 350.

FINANCIAL HISTORY

None of the founders had personal financial resources to contribute to the company's start-up costs. As a result, they gave their initial investors, who included a private venture capitalist and a medium-sized manufacturer, 90 percent interest in the company for the $250,000 they needed for start-up in 1962. Stock options to founders and key employees increased their potential interest from 10 to 35 percent.

From 1964 to 1968, the company raised an additional $800,000 to support general growth. It went public in 1977. Since the purpose in going public was stock liquidity rather than raising capital, the company issued no new stock, but simply registered with the S.E.C.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1962	0	0	0	8
1963	$ 100,000	25	0	8
1974	$ 7 Million	10	15	190
1979	$20 Million	10	15 (approx.)	352

GOVERNMENT INVOLVEMENT

During its early years, up to a quarter of the company's sales represented government R & D work. Because of the difficulties associated with background rights and patents, the company attempted to minimize direct government R & D contracts. The company left the government contract R & D market entirely during the early to mid 1970's. It is presently performing some research for government agencies who have recognized the company's need to protect its own technology.

Although the company does minimal direct government R & D, a portion of its product sales, especially for scientific instrumentation, are made to customers who are financed by government grants.

SIGNIFICANT EVENTS AND KEY FACTORS

According to Founder 2, the key factors in his company's success were its joint development programs, the focus of its research on products of commercial significance and its choice of markets.

The company's joint development programs, through which a sponsor covered most, but not all, of a project's R & D costs in exchange for a limited license to the technology, allowed the company to retain control of its technology. The company could then commercialize those aspects of its technology it found most profitable.

The development of the company's technology took many years and a significant investment. The key to success in the field was the company's consistent focus on an ultimate product that was both unique and had well defined markets, and constant reassessment of that product within the constraints of the market.

The company's choice of markets was also important. Instead of approaching a major market that was slow moving and difficult to enter, the company looked for smaller markets that would respond quickly to technological innovations.

CASE #15

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company is now a leading R & D firm in acoustics and computers (information science) with over a thousand employees. It grew out of the part-time consulting work of two university professors who formed a partnership in 1948 when one of them received a major acoustical design contract. Between 1948 and 1953, when the company incorporated, the first two founders received considerably more contracts and brought three former graduate students into the partnership. They also developed a product whose royalties allowed the company to bypass venture capital completely in its early financing needs in the 1950's.

During the 1950's, the company firmly established its reputation in architectural acoustics and noise control doing primarily consulting and contract R & D. In 1957, it made a foray into psycho-acoustics which gave rise in the 1960's not only to an expert department of psycho-acoustics, but also to the company's whole computer operation.

The company went public in 1961. Its employment has grown steadily over the years. The applied nature of its work and its expertise in the field helped the company escape the financial ravages of the Mansfield amendment and Nixon's drastic cuts in research spending. The company has also been a leader in technology transfer and has set up a number of successful subsidiaries to exploit and commercialize spinoff technologies.

The company's fundamental technology came from its initial founders' individual academic work and their early collaboration. The first two founders had worked together during WWII, and afterwards established an acoustical laboratory at the university. In addition to their research, they did regular outside consulting.

Although most actual technology is developed within the company's labs, the university "connection" was, and is, an important contribution to the company's technological development. During the 1950's, four of the staff held full-time or adjunct faculty positions. Even today, when only one of the founders is still teaching, the company maintains close ties with the academic community. This provides the company with new ideas and a source of highly qualified employees.

The technological event that catapulted the company to the forefront of engineering acoustics was the development of the jet engine. The original partnership received a contract from NASA to control the noise created in its Cleveland wind tunnel when jet engines were being tested. The expertise the company gained through this contract had two very important results. The first result was the establishment of the company as experts in the field of jet engine noise. They had an influx of contracts for the reduction of internal and environmental noise from jet engines. The federal government was their primary client, but the company was also hired as a consultant to major airplane manufacturers, airports, and communities affected by jet landing patterns. The company's efforts in quieting jet engine noise also provided technology which could be transferred to its work in other areas of acoustical engineering. The second result was the development of a pre-packaged noise reduction system for jet engine test cells. The demand for this product was so high that its royalties provided the company's early funding required for growth.

In 1957, the company decided to expand into the field of psycho-acoustics. The equipment the company's researchers used to study the human perception of sound included one of the early second generation computers. In designing the software for their experiments, these scientists became excited with the computer technology itself and aware of its tremendous technological and commercial potential. The company established a burgeoning computer division and began applying computer technology to the many other facets of its research.

The company's computer work, both directly and indirectly, gave rise to marketable technologies. When such a technology was identified as with time-sharing in 1963, and packet switching in 1973, the company set up a wholly owned subsidiary to exploit it. A few of the company's researchers moved on to the subsidiary, but for the most part, they provided consulting, advice, and basic technology to the new staff hired for the subsidiary. Eventually, most subsidiaries were sold to individuals or larger firms that would develop the technology further.

FINANCIAL HISTORY

Fortunately for the company, royalties from an early product enabled it to bypass all initial venture capital. Contract work was a constant and growing source of funds. Whenever cash flow became a problem in the 1950's, the company took out commercial bank loans. The only time it received any major outside funding was when it went public in 1961. The $2 million the company made in its first public stock offering, however, was incidental to its primary motive for going public. The company wanted to offer stock options to attract key personnel, but such options are more meaningful with liquid stock on the public market.

While the company never had to seek direct outside funding for itself, it did go to venture capital to finance its subsidiaries. It was very careful to bring outside financers in slowly, however, in order to retain control of the subsidiary. In one case in which the company had invested $250,000 of its own in a subsidiary and raised $25 million for it in outside financing, the company eventually realized a net profit of $14 million from the subsidiary's sale.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1961	$ 2 Million	65	111
1979	$ 37 Million	80	1,000

GOVERNMENT INVOLVEMENT

Government R & D contracts have always represented a high percentage of the company's sales. Throughout the 1950's and early 1960's, most of these contracts were in response to unsolicited proposals to various agencies, especially NASA, DOD, and NEL. Later, the contracts more often followed government solicitations, but government R & D contracts have consistently accounted for 65 to 80 percent of the company's sales, with 80 percent being the most recent figure. This very consistency renders the company somewhat of an anomaly among the companies in our study. The Mansfield amendment in 1965, which radically curtailed R & D contracts to many firms, had no effect on the company since all of their research is applied and so was considered mission oriented.

SIGNIFICANT EVENTS AND KEY FACTORS

The four key factors in the company's success were the coincidental development of its acoustical expertise with the development of the jet engine; its decision to explore psycho-acoustics; the availability of unsolicited government contracts in the 1950's and early 1960's; and the company's relationship with the university.

During the 1950's, the company dominated the market in jet engine noise control. A key government contract in 1951 established the company's primacy in the field. This enhanced the company's overall reputation, improved its technology, increased profits, and guaranteed further contracts.

The 1957 decision to enter the field of psycho-acoustics also induced the company's entry into the computer field. This gave rise to a very profitable computer division. It also markedly augmented the company's capabilities in other fields (e.g., acoustic engineering).

The availability of government funding for unsolicited research proposals during the 1950's and early 1960's contributed substantially to the company's success. The company developed much of its technology and expertise under government contract. It has very effectively transferred key portions of this technology to the marketplace.

The company has a very strong policy of backing promising technologies through spinoffs. This is one of the most successful methods of technology transfer that we have encountered in our study. It is also interesting to note that while the company has provided spinoff technology for other firms to acquire, it has never gained technology through acquisition.

The company's performance in transferring technology gained under government contract provides a strong case for government support for technological development. In a number of cases the company has successfully commercialized a technology to the benefit of national technological development as well as the company's stock holders. Without the initial government R & D support, these technologies would not have been available for commercialization.

A further factor in the company's success was its relationship with the university which encouraged outside consulting. The company grew out of a part-time consulting partnership between two of the founders. In addition, four of the staff retained their faculty positions; their graduate students became a source of highly qualified technical employees.

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company is a small, privately held firm doing bio-medical research, and manufacturing materials for bio-medical research. It was founded in 1961 by a prominent academic in bio-chemistry. The founder had two major goals. The first was to get his research out of the university with its departmental and political strictures. The second was to move the technology he and his firm developed, out of the lab and into the marketplace, to the benefit of society and his own personal profit. He was confident that much of the contract research he had been performing for the government at the university where he taught would continue to be funded through his company.

The company's very basic technology came from the founder's academic research. The field was, and is, so fast paced, however, that the company's real breakthroughs were developed in its own labs. The availability of government R & D contracts for good, unsolicited proposals in the early 1960's made it possible for the founder to design research projects that would give his company the technical expertise necessary to maintain its vanguard position in bio-medical research. Even after the government curtailed much of its R & D spending and the company began to manufacture research materials, it maintained an extensive R & D program. The founder also works in close cooperation with the top scientists in the field. He is well respected both professionally and personally by his colleagues and they are able to share ideas and specific technological advice.

The company's financial success hinges on its ability to maintain a technological lead among others in the field.

At a low point in contract research, the founder decided to start manufacturing on a larger scale, the high quality materials the company had developed for its own research. Within a few years, the demand for research materials increased, creating a large market especially in university labs. The founder's university connections and the company's reputation for frontier research helped the company dominate that market. The company then went into large scale production, eventually becoming the leading, often sole, supplier of certain laboratory materials with current/annual sales up to around $5 million.

FINANCIAL HISTORY

The company's original financing came from a small group of private investors who gave the founder $50,000 for 20 percent of the company's stock. The founder used this to set up his research facility. The investors were surprised at the small size of the founder's request and expressed willingness to provide additional capital. The founder insisted he didn't need more. He planned to submit unsolicited research proposals and thus have the government fund the company's initial research and solve early cash flow problems.

Within eight months of incorporation, the company received its first government contract. The only additional financing the company ever received was a loan from the founder's personal funds during a particularly bleak period. If the company decides to implement its major expansion plans, it expects to go to the public market for funding.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1961	$ 500,000	100		10-15
1979	$ 5 Million	60	30	85

GOVERNMENT INVOLVEMENT

The government played and continues to play a significant role in the company's success. In the early years government support was direct. The founder financed all of his early research, and thus his company's acquisition of technical expertise, with government R & D contracts for unsolicited proposals. However, in 1965 the Mansfield amendment required that all federal spending for R & D for the Defense Department be directed toward solving a clear current problem. A number of long-range projects were terminated, leaving the company in a difficult position. The company was forced to re-evaluate its markets and objectives. The result was the gradual buildup of the company's capability to manufacture and sell biomedical research materials.

The company continues to perform contract R & D for the government. In addition, the government is usually the ultimate purchaser of the company's research materials, either directly through sales to national laboratories or indirectly through sales to government supported university labs.

SIGNIFICANT EVENTS AND KEY FACTORS

The critical factors in the company history relate to the availability of government R & D contracts at the time of founding, the abrupt cut back in government funding available in the late 1960's, and the close ties with the national academic community in the company's field of technology.

The company was started with minimal funding, just enough to put together a viable laboratory facility to satisfy government contracting officers. The easy availability of contract funds to a highly qualified researcher made the risk minimal. At that time, the government readily funded good unsolicited proposals, even from private industry. In 1965, when non-mission oriented research was curtailed, the company almost didn't survive. It turned to its ability, largely acquired under government contracts, to produce efficiently top quality substances for use in its own research for a viable product. These highly specialized, difficult to produce substances made their way into research facilities all over the world. The close connections maintained with researchers over the years gave them the access and reputation needed to sell their materials.

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company is now a leading R & D firm in the fields of medical technology and electronics. The firm grew out of the part-time consulting work of a university professor of mechanical engineering, and a previous student of his. This consulting continues to comprise approximately 20 percent of the company's work.

Organized in a casual fashion for the first three or four years, the company incorporated in 1957. Growing from its original base in contract research and development, the firm expanded into product manufacturing and marketing in the fields of health and communications. Today, the company engages in three principal lines of business: bio-medical products for the clinical laboratory and for cryosurgery, data communications products for communications and computer network control and testing, and R & D engineering services for industry and government agencies. Through four domestic manufacturing operations, eight foreign marketing subsidiaries, and other distribution outlets, it sells its products worldwide. The 1970's were a time of great prosperity as the firm rode the wave of technological growth to the point where they now have sales of $28 million (1979).

The company's fundamental technology came from its founders' individual academic work and their early collaboration. The firm provided needed research and development engineering services to industrial clients and government agencies. The company began to diversify in the mid 1960's into product manufacturing and sales. Health care became a primary interest and by 1970, the firm had emerged as a world leader in the field of cryosurgical and other medical instrumentation. Further diversification into network control centers in the field of electronic data communication was greatly aided by the acquisition of a southern firm which designed and built various pieces of electronic equipment, as well as providing communications systems.

In the bio-medical area, the firm has developed a system allowing performance of multiple clinical or research laboratory tests on small amounts of blood serum or other body fluids. Designed to increase speed, efficiency, and accuracy, while decreasing costs, this equipment finds wide application in fields of immunology, serology, and microbiology. The firm entered this field by acquiring a company whose products could be greatly improved by the application of sound engineering design. After redesigning the product, the firm was then able to enter the marketplace with a superior product that had far reaching applications. This pattern has been the model for the company's acquisition program and has been particularly successful.

FINANCIAL HISTORY

Because of the part-time nature of its early dealings, the company did not require any initial outside capital. The only form of financing used was through its cash flow. It wasn't until 1962, when business drastically slowed down, that the founders had to inject some capital. At this time, the founders stopped drawing salaries for six to eight months until business improved again. The company did resort to some financing in the mid 1960's in the form of convertible debentures. They were sold only to raise cash flow, and were bought back in the mid 1970's. At this time, they increased their bank loan to about $4 million, but presently that debt has dwindled to $250,000.

The company has generally profited from an extremely favorable cash flow, which allowed it to avoid constricting financial commitments and heavy indebtedness. Even when acquiring the southern firm, it did so with a combination of stocks and cash, avoiding any serious long-term debts. The firm went public in 1968 to make acquisitions easier to accomplish.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	$ DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1959	$ 150,000	40	5
1974	$ 9 Million	30	7
1979	$ 27.5 Million	30	800

GOVERNMENT INVOLVEMENT

Although, as a general rule, the company tried never to have more than 35 percent government business at any time, there were notable exceptions. The company was involved in the development of a mine sweeping device in the early and mid 1960's, which was a major source of income at the time. However, the general feeling was that dependence on government funding was a dangerous path to follow. Among the criticisms of government funding were a very slow payment process, and the problems resulting from government negotiating away any profits. Even taking these criticisms into account, government funding played a significant role in the growth of the company.

SIGNIFICANT EVENTS AND KEY FACTORS

The three key factors in the company's success were the absence of constricting financial commitments, acquisitions, especially that of the southern engineering firm with the subsequent interdependence between the parent and the acquired, and the company's relationship with the university. Due to the nature of the company's initial organization, a strong financial groundwork was developed very early. This generation of steady cash flow was employed as a means to avoid long-term debt.

The decision to acquire the southern engineering firm was an important factor in the company's take-off in the late 1960's. The idea of acquiring a smaller company to fill in the gaps of one's own organization is based on sound economic planning. In addition, the firm was able to acquire companies and, by using its strong engineering capabilities, improve the existing products and expand into new markets.

A further factor in the company's success was its relationship with the university. The company grew out of a part-time consulting partnership that was stimulated by the university's policy of encouraging faculty to spend one day a week on outside consulting. In addition, one of the founders retained his faculty position, and his students became a source of highly qualified technical employees.

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company is now a prosperous, technically oriented, international organization, employing over 15,500 people. Initially, the firm's three founders relied on one main product, the design and development of stroboscopes. As time evolved, serious diversification was undertaken, and today the company divides its business activities into five major segments: Instruments, Components, Environmental and Biomedical Services, Custom Services and Systems, and Department of Energy support.

The organization incorporated in 1948. At this time, the majority of their work focused on the stroboscope, whether employing the light techniques in consulting work, or developing the hardware associated with stroboscopes. In this early period, a major university was very supportive of their work, exchanging much needed lab space for some of the technology being developed. In 1949, a unique opportunity presented itself. A member of the Atomic Energy Commission became enamored of their tecnnological expertise and convinced the AEC to finance the firm's research as long as they would give a proper account of where the money was going. The university agreed to handle the paperwork, and the company undertook the contract to develop a component of the atomic bomb. At this time, employment grew from four or five, to eight to ten. This government funding lasted four years and laid a firm financial groundwork for further corporate development.

Soon after this project was completed, a related study pertaining to weapons testing developed, again funded by the government. Up to the late 1950's, no non-governmental work at all was undertaken. Eventually, the firm re-entered the commercial market, again relying on its work with stroboscopes as a base. Now, though the emphasis was much more on hardware and less on R & D, much of their commercial business was developed through acquisition.

The company's fundamental technology stemmed from teaching and research done at the university. All three founders were associated with the university, (and still are) and the role it played in the development of technology cannot be overemphasized. As mentioned, the development and utilization of stroboscopes was the groundwork for much of their early work and led them to work in night-aerial photography, radar, and aircraft gunsights. Projects that the firm explored throughout the 1950's were virtually all government funded. However, in the early 1950's, government funding of atomic weaponry emerged as the company's main revenue source and this technology remained at the top of the firm's priorities right through the 1950's.

Inevitably, this government work had to slow down, and when it did in the late 1950's, stroboscopes again became the main component upon which the business revolved. With successes in both the governmental and commercial fields, sufficient capital had been generated to pursue an active acquisition policy through the 1960's and 1970's, significantly developing their technological breadth. Today, the company's technological developments include manufacturing of nuclear and electronic measuring equipment, the production of geophysical survey instruments, flashtubes, photodiodes, image sensors, and mechanical seals. The firm also provides consulting for national defense, physics research, space exploration, and environmental programs.

FINANCIAL HISTORY

The corporation started with no more than $30,000 in working capital, and until the company went public in 1967, this was an instance in which the founders had chosen to invest their own funds in the organization. In the early years, the overhead was essentially non-existant, with the university supplying them with lab space and secretarial assistance, and with the government allowing them to finance all their work with public funds. It was a very unique and enviable situation. Largely due to these factors, and also because of a strong asset management program, the growth level maintained throughout the 1960's and 1970's was completely financed by internally generated funds -- so much so in fact, that their corporate debt today is nearly zero. For a company of this size, this is a remarkable achievement. In 1976, they bought back most of their shares of stock for approximately $30 million, with short-term loans, and before the year ended the loans were paid back.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	$ DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1947	$ 500,000	95	5
1974	?	?	10,000
1979	$ 522 Million	45	15,500

GOVERNMENT INVOLVEMENT

As already stated, the firm was virtually "set-up" by the government. A better case for the influence of government funding would be hard to find. The government was willing simply to arrange for a bank account in the firm's name. All the founders had to do was ask, and more money would be deposited. This is an indication both of the relative importance of the project assignments, and the extent to which the government was impressed by the founders' expertise in the field. The assistance offered involved both heavy funding, and a ready supply of quality employees. The current chairman of the board and chief executive officer was originally assigned to the firm by the government. It is impossible to underestimate the role the government played in establishing the firm.

As time progressed, the firm diversified into more commercial fields. Today, government business accounts for less than half of their sales, with about 50 percent of this business in research and development, and about 50 percent in hardware. The work is primarily done in the fields of energy and defense. The firm's founder emphasized the balance that is now kept between commercial and government work. While attempts have been made to use technology developed for the government in commercial applications, they have been largely unsuccessful. The work has just been too specialized, with too many performance requirements.

SIGNIFICANT EVENTS AND KEY FACTORS

The three key factors in the company's success were the role of government funding, the support that the university offered in their early development, and the founders' attitude in setting priorities.

The importance of the firm's government funding should now be obvious. For the first ten years after the company incorporated, government money constituted 95 to 100 percent of their revenue, and laid a firm financial base for further diversification.

Like many other high-technology companies, the role of the university in the company's initial struggle for acceptance is extremely important. By both furnishing lab space and secretarial assistance, it gave the founders a frambwork around which to organize itself, essentially, free of charge. In addition, the university's policy of encouraging faculty to spend a day a week on outside consulting surely played a role in the company's formation. All three founders are still associated in some capacity with the university.

A less tangible reason for the firm's success relates to attitude. The founders were more interested in solving problems than in making a lot of money, and this kind or orientation was infused into the employees' priorities, fostering a very healthy technological atmosphere. The fact that the three original founders remained together through the years is testimony to the healthy attitude the founders took upon entering the business world.

CASE #19

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1970 as a pharmaceutical research and development partnership by four entrepreneurial scientists from industry and academia. For the early years of its existence, it was primarily funded by a large chemical concern. The company subsequently incorporated as it got further into development and marketing. At that time, the company also made a conscious policy decision both to expand its contract research operations and to direct its own R & D towards a commercializable product. The company has since significantly expanded its drug development and testing capabilities. It currently uses a variety of corporate and other capital sources to finance the development and market entry of new drugs without relinquishing any equity.

The company's basic technology came from the founders' work at the R & D firm which they left in 1970. Prior to 1970, the founders and several co-workers who left with them were involved in drug development work for the U. S. government, including the Department of Defense. D.O.D. made an abrupt policy change which had a significant impact. The results of the previous research were declassified and the current contract work was discontinued. As is standard D.O.D. policy, the company was given the commercial patent rights to the technology they had developed under their government contracts. This opened up a whole new body of drugs for further research and commercial development.

The original R & D firm was willing to license the technology to the founders, when they decided to strike out on their own.

The founders planned to continue this line of research then pass drug possibilities on to a major drug company to test, manufacture and market. It was with this goal in mind that the company entered into a long-term R & D licensing agreement with a major chemical concern. Following the early years it became evident that the company could assume its own marketing activities.

After the long-term agreement expired, the company was able to exert greater control over its activities and is well on its way to commercial products with a variety of corporate and individual partners.

FINANCIAL HISTORY

The company's entire financing to date consists of a $10,000 - $20,000 loan made by one of the founders and repaid within three months. Of that sum, part went to the founders' former employer for licensing of technology, and the rest went to cash flow. This unique financial history was facilitated by the long-term development and licensing agreement the founders struck with a major chemical concern before they had even formed their partnership. The agreement obviated initial expenditures for lab space and equipment. By the time the company moved into expanded facilities in the late 1970's, it had acquired sufficient sales and profits to self-finance the move and expansion.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1970	$ 250,000	0	10
1979	$ 1.2 Million	10	30

GOVERNMENT INVOLVEMENT

The company has done very little contract research for the government. In 1970 it did none; in 1973 government work represented five percent of the company's sales. In 1979, government work represented 10 percent of sales.

Government contract R & D, however, was the source of the company's original technology. The founders were able to build the company on almost ten years worth of basic and applied research on chemistry and pharamcology of a particular class of drugs, all performed under government contract. Thus, government R & D was integral to the company's development and it could not have been done without the commercial and patent rights from D.O.D.

SIGNIFICANT EVENTS AND KEY FACTORS

The key factors in the company's development were its original government sponsored technology, its initial facilities agreement and the ultimate redefinition and clarification of its goals and business plan.

While the company did not start out with a well defined product, it was not working in the dark. The founders' work for their former employer under government contract had established the feasibility and basic technology for the type of drugs the company sought to develop. This original research would not have been within the financial capabilities of the founders.

The company's initial facilities and marketing agreement provided a financial cushion while the company established its credibility in pharmaceutical research, secured other clients and brought sales and profits to a level that would permit self-financing of later expansion.

Innovative technology and sound financing alone are never sufficient to propel a firm from small scale contract R & D to major corporate success. A firm needs a clearly defined product and market and a clear but flexible business plan. The company's satisfaction of these requirements has already netted positive results and should continue to aid the company's success.

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company grew out of a graduate student's thesis work on a technique for detecting trace metals in body fluids and other liquids. His anodic stripping voltammeter was so much more effecient and cost-effective than extent methods for trace metal detection that he and three fellow graduate students decided to form the company to bring this technology to the medical instrumentation market. Between this decision and the company's actual start was a two year hiatus during which the four intended partners scattered to teach at various universities. In 1970, the founder returned with one of his own graduate students to set up shop. With some help from family and from professional management which joined the company within the year, all the start-up capital for the corporation was provided from personal funds. This bootstrap operation was soon producing anodic stripping voltammeters.

The company's original markets were diverse and within a year, the company was delivering anodic stripping voltammeters to medical centers, hospitals, public agencies, and food manufacturers. Within that same year, the company began to show a profit pattern that would support a 50 percent aggregate annual growth rate without additional outside financing.

Although the company produces electroanalytical equipment for general testing purposes, it operates most effectively when addressing a particular problem. The company's first major project came with the advent of public concern over lead paint in older buildings and the consequent high levels of lead in the blood of inner-city children exposed to paint chips. The founder believed that the ASV was particularly well suited to the problem. It also coincided with the founder's desire to investigate the use of technology for the solution of problems that were essentially social in nature. The company began to work closely with various federal and city public health agencies to develop an effective lead testing program. The founder and his scientists refined the ASV, widened its capabilities, drastically reduced the cost of each test, increased its speed so results could be read immediately, and made units that were light and portable. Public health workers could now bring the ASV to individual field clinics making the lead testing program truly comprehensive.

Its work with the blood lead testing program provided the company with technological and financial impetus. This work also established the company's precedence in the field of trace metal detection. The company now has an uncontested international market for its devices, and it also has a test lab facility to serve those groups that need too few tests to purchase their own equipment.

The company invests at least 25 percent of its sales in R & D. The founder estimates that the company produces a major breakthrough at least every other year. The most recent is a device that tests for iron levels in blood serum at 50 percent of the former cost, and ten times the speed.

EMPLOYMENT HISTORY

YEAR	TOTAL EMPLOYMENT
1970	2
1974	30
1979	100

GOVERNMENT INVOLVEMENT

Although the company's technology is used primarily for diagnostic testing and is particularly applicable to large scale screening, it is infrequently funded directly by public funds. However, the increased awareness of the hazards of lead and the willingness to use public funds to try to deal with the problem, has clearly had a positive effect on the company's initial development.

SIGNIFICANT EVENTS AND KEY FACTORS

The founder was particularly interested not only in starting his own company, but in using his technical knowledge to solve some of society's problems. He looked around for ways to use his technology for the public good and even during graduate school directed his efforts in that direction. It was, and is, his opinion that a small private industry with profit as an absolute yardstick of the utility of a technology and with a minimum of red tape in development and implementation was the best vehicle to implement this goal. The identification of public needs followed by the development of the necessary instrumentation has been the clear impetus for the company's growth.

Another key factor in the company's growth was the recognition of the need to bring professional management, marketing, and financial people into the company immediately.

CASE #21

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1946 because two university professors (Founders 1 and 2) wanted to bring their atomic/electronic technology to the market. They convinced a colleague and former associate (Founder 3) that the venture held great potential benefit for society. They also convinced him that the venture's success would hinge not only on their own inventions, but equally on the effective management of a scientist/president.

All of the company's original technology and many of its later technological developments came from the university research of Founders 1 and 2. The university had transferred management of patents in this field to an independent corporation. At the time of founding, the company entered into a special agreement with this corporation that guaranteed (as closely as was legally advisable for the university as a non-profit institution) exclusive license to the company for those patents of Founders 1 and 2 upon which the company would base its technological development.

Founder 1, a physicist, made his first technological breakthrough in 1931 when he was a graduate student. He continued to pursue the same line of basic research for the rest of his life. Founder 2, an electrical engineer, was an early co-worker of Founder 1, who later became a professor at the same university. In the 1930's, he conceived of applying Founder 1's technology to cancer therapy. He began developing specific equipment for this use. By 1940, he had delivered units to three hospitals.

After a four year interruption caused by WWII, Founder 2 returned to his cancer therapy work. He realized that for the technology to have any impact, he needed to move it out of the university lab and into development and production. The company was founded with this specific application in mind.

The company's first "plant" was in a Cambridge garage. Founder 3, as president, was the first full-time employee. Founder 1 served as chief inventor -- Founder 2 as technical director and chairman. No one drew a salary the first year, but Founders 1 and 2 continued in their university positions. By 1948, however, it became clear that other technology would capture the market for cancer therapy. At this point, the company began developing major equipment for university research labs. The company was reinvesting a record 12 percent of its sales into this research and development. In addition, there was a fairly fluid transfer of useful technology from Founder 2's privately and government supported university research lab.

Besides the transfer of technology from the university, and its own unusually high internal R & D, the company also gained some new technology through the acquisition of a smaller company. This acquired technology combined with extant technology, forms the basis for a product line of plastics and accessory equipment that the company began manufacturing in the mid 1960's. The company is now a leading manufacturer of a variety of electric and electronic equipment. Founder 1 eventually left his university post in 1953 to devote his full energies to the company's research. Founder 2 continued his teaching and research at the university in addition to his role as scientific director of the company.

FINANCIAL HISTORY

The company received its original funding of $250,000 from a private venture capital firm and another investor in return for 60 percent of its outstanding stock (48 percent and 12 percent respectively). The funds were applied to capital equipment purchases, establishment of research facility, product development and the working capital to start the company on its first product.

Although the company began showing a profit in the second full year, it continued to have cash flow problems. The company was researching, developing and producing very large expensive pieces of equipment for which it received progress payments that were insufficient for its working capital needs. In 1953, a group of wealthy private investors provided the company with $500,000 new capital. In 1955, this same group invested a further $920,000. In 1961, the company secured a $3 million loan in the form of convertible subordinate notes from a large insurance firm, again for cash flow purposes. The insurance firm saw a great potential in the high technology industry, and in particular in the company. The terms of the loan were very reasonable: 12 years at 4-3/4 percent and a stock option. In 1963, with a fairly secure financial base, the company was listed on the New York Stock Exchange, but without any additional stock offering for the purposes of stock liquidity and acquisitions.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	$ DIRECT GOVERNMENT	$ INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1947	$ 2,165	0	0	3 to 25
1974	$ 41 Million	Small	Small	1,350
1979	$ 65 Million	Small	Small	1,924

The company's original market consisted of hospitals pioneering megavolt cancer therapy. When advances in other modes of cancer therapy forced the company to seek other markets, it found ready customers in university labs doing atomic/electronic research.

1964 witnessed a dramatic cut in university research budgets due to government cuts in university research support, which again forced the company to seek other products and markets. During the transition period, 1964 to 1965, the company's annual sales to U.S. customers dropped precipitously and foreign research institution sales kept the company going.

GOVERNMENT INVOLVEMENT

Throughout most of its 34 years, the company has had no direct government R & D contracts. It has, however, greatly benefited indirectly from government R & D spending and suffered from government R & D spending cuts. The company's great financial success in the 1950's and early 1960's was based on university expenditures for capital equipment. These expenditures were made entirely out of government R & D grants. When the federal government cut awards to university research labs in the early 1960's, the company lost its major market. The company was then forced to find other markets to broaden its product line.

Besides affecting sales, government R & D spending had an impact on the company's technology. Founders 2 and 3 had gained some of thier original expertise in government sponsored labs. To this day, Founder 2 conducts university research under government R & D contracts and concurrently stimulates engineering development at the company. Finally, many of the research scientists who come to work for the company were trained in government sponsored university labs.

SIGNIFICANT EVENTS AND KEY FACTORS

A crucial factor was the nature of the investors in the initial funding round. Both understood the problems of the company's particular field of technology and its long gestation period. Both were willing to wait patiently instead of making unrealistic, early profit demands that could have caused the company to fail. The only contingency of this round of funding was that the company secure exclusive license of the founders' patents held by an independent corporation for the university. The ability of the company to obtain the practical equivalent of patent rights from the university was attributed to the close connections and mutally supportive attitudes among the founders, the university and the major capital source.

The close involvement and interaction with the university has continued to play an important role in the company's development. It has provided an excellent mechanism for technology transfer and has enabled the company to attract some of the best people from the university for its engineering staff.

It is important to note the extremely long gestation period in this field of technology. Despite the company's tremendous R & D expenditures, availability of inventions brought in from the university and technology gained through acquisition, many of the founders' original ideas are just now coming to fruition, while others could remain in the research stage far into the future.

CASE #22

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company grew out of a unique university laboratory that during the 1950's did extensive contract work for the Air Force. The hundred or so engineers, scientists and technicians from diversified fields brought in $1 million worth per year of contracts primarily for optical research and equipment. The lab was also in the forefront of aerial reconnaissance, a field that combined optics and information technology.

In 1957, two former associates of the lab, Founders 1 and 2, conceived of founding a company to exploit a perceived market for graphic information systems in the military's arms control programs and for commercial markets. In September of 1957, they established the company with financial backing from a major private venture capitalist. A few of the lab's scientists joined the venture. On January 1, 1958, the company negotiated a transfer of the lab from the university; with few exceptions, the lab's entire staff also joined the company.

Corporate status made possible the wide expansion of the lab's work both in terms of classified contracts and actual production capacity. It was the general furor created by Sputnik, however, that really catalyzed this expansion into the company's phenomenal early growth. Within a year, sales had reached $3.5 million, employment 100. By 1959, sales reached $25 million, employment 1350.

While the company greatly increased its aerial reconnaissance work for the Air Force, it also initiated an acquisition policy that expanded its capabilities into a variety of related fields, many with commercial applications. Thus, within a few years of founding, the company consolidated its preeminent position as a developer and producer of optics and information systems for the government and established strong positions in business equipment and vision care products.

During the 1960's and 1970's, the company continued to extend its capabilities within its various branches as well as to make additional acquisitions. The company consists now of four major divisions: graphic products, vision products (largely commercial), and applied technology optical systems (largely government), which serve both government and public markets. The company's annual sales in 1978 reached a record high of $265 million.

The company's original technology came from the aerial reconnaissance work of the university lab that formed the company's nucleus. A unique aggregation of expertise in a broad range of fields from physics and electronics to optics and chemistry existed in this lab. Its scientists and technologists also exhibited a tremendous ingenuity, motivation and cooperation. The result was an unmatched ability to address very complex problems, and develop the necessary processes and equipment to solve them. In addition, the company had a science advisory board that consisted of some of the nation's top scientists. The company's output on its government R & D contracts during its early years was phenomenal.

The company's acquisitions often had no direct technological connection with the company's original work. The same expertise and motivation that lent brilliance to much of the company's aerial reconnaissance work, however, also led to the technological and fiscal success of the company's acquisitions. For example, in 1958, the company purchased a failing business whose main product, copying equipment, had become obsolete. The central research group was able to apply computer technology and general expertise in a variety of fields to develop the basic equipment that raised the company's graphics division to national importance.

As the years progressed, the company continued to expand through acquisition. Although the company continues to perform considerable contract R & D for federal agencies, primarily the Air Force, by the mid 1970's, it had become too large and diffuse to maintain a central research facility that served all divisions. Individual divisions now maintain their own

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research groups. While the disbandment is in accord with the company's corporate structure as it has lately evolved, Founder 3 saw it resulting in a sharp decline in the truly creative work made possible by the synergism of the company's original research team.

FINANCIAL HISTORY

The company's original financing was a $180,000 investment, soon raised to $600,000 by a private venture capitalist who enjoyed "way out" projects. He received 15 percent of the company's original stock. The level of sales induced by Sputnik was so large that within three month's of founding, the company was able to go public. The company offered its stock at $21 a share. Eventually the stock was split five to one. In 1966, the company entered the New York Stock Exchange. Aside from the original venture capital funding and public stock offering, the company has been able to maintain its growth on its sales revenues.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1958	$ 3.5 Million	100	500
1959	$ 25 Million	60	1,350
1974	$ 197 Million	50	5,853
1978	$ 265 Million	35	6,282

GOVERNMENT INVOLVEMENT

The company's involvement with government R & D contracts predates even the university lab's aerial reconnaissance work. That lab of 100 engineers and scientists originated from a small optics lab at another university set up by the Air Force during the Second World War. The optics lab moved from the first university which no longer wanted to be involved in classified work for the Defense Department to another in 1947. By 1957, its staff had expanded from 15 to 100 and it had accrued approximately $1 million per year in primarily sole source R & D contracts for the Air Force. Within a year of the company's founding, R & D contracts totaled $3.5 million.

In essence, the company's original technology and basic staff capabilities were developed under government contract. Large government contracts in the early years served the additional function of providing a financial cushion while the company acquired and developed its various subsidiaries. Government sales continue to be important to the company, representing approximately one third of its total sales.

SIGNIFICANT EVENTS AND KEY FACTORS

The key factors in the company's success were its unique research staff, government R & D contracts, especially in the wake of Sputnik and the company's policy of expansion through acquisition. The first two factors are very closely related. The unique aggregation of scientists and engineers produced phenomenal results for the Air Force which engendered further contracts for aerial reconnaissance and other research work. The government R & D work formed the basis of the company's technology and provided a financial cushion for early expansion into other fields. The general technical expertise of the research staff allowed the company to introduce the technological improvements to transform its acquisitions into financially and technically viable divisions.

The company's acquisition policy was also central to its great corporate success. The company is able to tap vast commercial markets in a variety of fields and to reduce its financial dependence on generally less predictable and remunerative government markets.

CASE #23

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company is a small physics and engineering firm doing basic and applied research for various agencies of the federal government in the fields of energy technology, environmental sciences, laser devices and applications. The company was founded in 1973, when six scientists at a major research facility became disenchanted with their employer's increasing emphasis on hardware development and commercialization. They saw the facility's goals as eventually becoming too diffuse to produce either state of the art research or a viable product. The founders left the facility to start their own company focused only on contract research and development.

The founders spent their first six months writing proposals. By the end of 1974, the company had received research contracts totalling $385,000. By 1979, sales reached $2.4 million and employment had risen from the original 10 to 46.

The founders brought the company's basic technology with them from the previous employment. The company's present technical capabilities, however, are the result of a very careful strategy in their contract research. The company's work with fuel cells is illustrative of this process which extends over all the company's research efforts.

When the Department of Energy initiated its program of fuel cell development, the company wrote a research proposal for an aspect of fuel cells easily within their technological grasp. Through this contract, the company gained access to the other aspects of fuel cell technology. The company used this as a base that has led eventually to its work on most aspects of second and third generation fuel cells. In addition, the mathematical modelling the company developed for fuel cells has led to a number of spin-off technologies.

The company's research staff consists almost entirely of Ph.D.'s at the forefront of their particular scientific fields. The company is run much more like an academic institution than an industrial research facility. Since the company is not concerned with commercialization, it freely disseminates non-classified findings. The company encourages its staff to participate in scientific conferences. The company runs a regular distinguished speaker series to help its staff keep up with new technological and scientific developments. The company also encourages its researchers with complementary expertise and capabilities to work together on projects, which results in more creative and often more rapid solutions to complex problems.

FINANCIAL HISTORY

The company's only financing was the original $70,000 the six founders put up in 1973 for equity in the company. They used this money to pay their own salaries and that of a secretary while they wrote proposals for research contracts. In the beginning, their research was almost entirely theoretical, so did not require equipment expenditures. As government contracts increased, the company began to acquire experimental equipment through the contracts, which became part of the company's available research facilities. The company also gained access to very advanced equipment and devices at government research laboratories.

The company has never had to seek additional financing. It has been able to support its annual growth of over 30 percent on its own sales revenues. Founder 1 ascribes this success to the company's strong research capabilities and securing contracts from three federal agencies. and enough different departments within those agencies, that the loss of any single contract would have minimal financial repercussions.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1974	$ 385,000	100		10
1979	$ 2.4 Million	80	20	46

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GOVERNMENT INVOLVEMENT

The company was founded to perform contract research and development for the government. With the exception of a few minor industrial contracts, government R & D represents the company's entire sales and is projected to continue to do so well into the future. About half of its work is for the Department of Defense, 40 percent for the Department of Energy, 10 percent for NASA. Within each agency, the company has many individual contract sponsors.

In addition to its present dependence on government contracts, much of its original technology had also been developed under government contract. Like the company, the founders' former employer depended heavily on the government for support of its research.

SIGNIFICANT EVENTS EVENTS AND KEY FACTORS

The company attributes its success to a very clear focus on its corporate goals, a rational strategy for acquiring contracts and technology and the technical competence of its research staff. The company was founded by research scientists who knew that their strength lay in innovative advanced research. They were not interested in commercialization and knew that they did not possess the business acumen and financial wherewithal to translate their research findings into a viable product. They made a conscious decision, therefore, to concentrate the company's efforts on contract research.

The company's strategy in seeking contracts is also important to its success. The company secures contracts based on existing technical capabilities that will help extend those capabilities as well as give the company access to new technology. The company also secures contracts from many different sources so that only an across the board cut in federal research allocations would have a severe financial effect on the company.

The third factor in the company's success is the high quality of the company's research staff. Their tremendous expertise and ability to approach complex problems with creativity and insight have strengthened markets for the company's research.

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in late 1968 by a recent Ph.D. from a local major university. The initial funding was provided by a large manufacturing firm for whom a relative had worked in return for 60 percent of the equity. The founder saw a need for better consulting in environmental quality matters and felt from his technological background in nuclear physics, meteorology and geo-physics that with a little time and financial support, he could develop improved consulting methodologies and monitoring systems.

Within a few months, government contract funds were received and provided the continued financial support necessary to develop this technology. At the same time, the company started to use its technology to assist industry solve problems related to pollution control engineering. The advent of increased concern for environmental quality and the corresponsing tightening of environmental standards and regulations provided a ready market in the private sector for the company's services.

Over the years, the company has had many government contracts with a number of agencies but has always done most of its work for private industry. Initially, it established its technical reputation by providing air quality consulting and monitoring services to utilities and highways agencies. Gradually, its related computer capabilities expanded so that it is now involved in the integration of data collection, processing and analysis for complex environmental studies.

Early in the company's history, the original investing firm was bought out. The company has had steady growth over the years, twice requiring additional capital to keep up with its increasing cash flow requirements. The one difficult period occurred in 1974, when the financing for a large contract requiring expensive new equipment fell through. Attempts at the construction and sale of hardware were unsuccessful and looked unlikely in the future. Recently, the company merged with a much larger, public corporation that can use the technology and has sufficient financial resources and orientation to get hardware to the market.

FINANCIAL HISTORY

The company was founded in late 1968 with the equivalent of $150,000 provided by a large corporation for a 60 percent share of the equity. The funding was not cash; it was budgeted on an "in kind" format. These funds were not sufficient to keep the business operating, and the firm survived on a number of small loans during the first year of operation. Within two years, the firm was able to survive on its own revenues, and it bought back the 60 percent they had originally sold to the investor.

By 1972, the company had developed a solid framework for growth, and any other private financing they have received has been growth oriented. In 1972, the firm received about $300,000 in private funding, and in 1973, an additional $500,000. These influxes of outside capital were compensated with about 30 percent of the company's ownership.

The company experienced a severe financial squeeze in early 1974 when financing for a large contract requiring expensive new equipment fell through. By stretching its payables, the firm was able to weather the crisis, and by early 1975, was again on a firm financial base.

The firm has been expanding rapidly since 1972. In 1977, it merged with a large firm, with the merger presenting some formidable financial resources.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1969	$ 119,000	45	34
1975	$ 4 Million	35	200
1979	$ 32 Million	20	700

GOVERNMENT INVOLVEMENT

The founder emphasized the important role the government played in the company's early history. Even though it seldom constituted more than 35 percent of sales, the work came at very opportune times, and led to a number of technological developments instrumental to the firm's growth. The government contracts were self-developed, and were not a result of special "connections". The founder pointed out the healthy technological atmosphere in the late 1960's and early 1970's. Essentially, the firm would appeal to the government with a strong marketing effort behind a unique idea, which at the time was sufficient to achieve much needed funding.
The founder felt that today, the more innovative an idea, the less chance it has of being funded. Today's high-technology market is mired in conservatism and afflicted by the preponderance of **earmarked** , government proposals, aiding the large entrenched company, and hurting the small innovator.
Government business for the firm still accounts for about 20 percent of sales, but its orientation has changed markedly. Their use of patents has been extensive, with a great deal of success. They have never made money on patents per se, but their existing patents have never been infringed upon, and have been an important tool in protecting technological developments.

SIGNIFICANT EVENTS AND KEY FACTORS

The three key factors in the company's success were the recognition of a market need, the availability of government funding in the development of technology; the emergence of a prosperous market in the company's field of specialization; and the entrepreneurial role model that the founder's father offered.

The founder identified needed but not yet available technology that was within reach, and set out to develop it. The company was able to finance some of the critical technological development through the funding of unsolicited proposals by the government. The founder pointed out that in the company's early years the government would frequently fund an innovative idea with no assurance of success. The founder's family background had a significant influence on his willingness to accept risk and possible failures as a cost of directing an innovative company. The founder's father had been involved in a number of entrepreneurial business ventures and the founder was oriented toward running his own company.

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company is now a major corporation with somewhat disparate, but highly successful components. Its present work in construction, broadcasting, nuclear and solid state products, however, is completely unrelated to the company's original technology and business plan. When the four founders left their former employer in 1951, they had hoped to perform extensive government R & D contract work for the first few years, thereby gaining the necessary expertise and technology to commercialize a product. Although the company maintained its software division until 1968 and its advanced research group until 1973, neither of these divisions, both of which had been involved in government contract R & D, ever achieved the sales levels the company sought or translated into a commercially viable product. The company's presently successful divisions were all acquisitions, as was all the technology used by those divisions.

FINANCIAL HISTORY

During the company's first few months, while the founders submitted research proposals to government agencies, they supported themselves with per diem consulting work for the Air Force. Once the company began to receive R & D contracts, it needed capital to finance laboratory and office space, laboratory equipment, support staff, cash flow. At the end of its first year, 1951, the company raised $160,000 with a public stock offering. In 1956, the company raised an additional $600,000 by selling to each of two major corporations a 20 percent interest in the company. Since that time, the company has supported all growth through internally generated sales, and a series of mergers and acquisitions.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	$ DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1951	$ 250,000	100	8
1979	$136 Million	5	1500

GOVERNMENT INVOLVEMENT

The company depended heavily on government contract R & D in its early years. The founders had developed their original technology under government contract while they worked for their former employer. They did consulting work for the Air Force to support the company during its initial few months. The company's sales during its first few years were almost entirely government R & D contracts. The company's other divisions fairly rapidly surpassed governemnt R & D divisions in sales, and the company was never able to commercialize government sponsored technology. The initial government contract work, however, provided the financial cushion until the company clarified its goals and was able to move into large scale manufacturing of acquired technology as well as into the radio and construction businesses. The situation points up the problems faced by scientists and engineers when they try to bridge the gap between contract research and commercialization.

SIGNIFICANT EVENTS AND KEY FACTORS

The founders attribute the company's present phenomenal success to their decision to abandon contract R & D, their decision to give up control in order to raise capital in the public market, and the company's great diversification.

While contract R & D had gotten the company off the ground, over the years it had become more restrictive, and less remunerative. It became clear that the company would never begin to approach the targeted billion dollar sales figures if it remained in that market.

In order to become established on a scale that would lead to major corporation status, the company needed more financing than either the founders, government contracts or small private investors could supply. To go the public market for the requisite capital, however, meant relinquishing most of the founders' personal control over the company. This decision, however, has made it possible for the company to reach some of its corporate goals.

Finally, the company's divisions each represent very different fields of technology and business. Such diversification strengthens the company's overall competitive advantage.

CASE #26

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company is an R & D firm that develops systems and software primarily for government agencies. It was founded in the mid 1960's when several engineers at a local research facility became dissatisfied with their jobs and wanted to run their own company. This entirely self-funded group received its first contract after six months and showed profit after the first year. The company has both broadened and intensified its markets and extended its technical capabilities. It has exhibited an annual aggregate growth rate in sales and employment of 30 percent but has never had to seek outside capital.

The company designs systems and software for the solution of various problems often associated with defense operations. This work most often involves paper, pencil, laboratory experiments and computer time. The company's original general technology thus consisted not of patented processes or equipment, but rather, the expertise and knowledge of its founders. The company's technological, and thus financial success, however, arose from successful applications of a theoretical breakthrough in computation made in the same time frame as the company's start.

While the company's technological basis was originally focused upon this computational breakthrough, the company has sought very broad applications that draw on employees' expertise in a variety of fields. Among the techniques the company uses are mathematical modeling, systems analysis, economic analysis, engineering optimization, management science, and computer simulation. The company builds on its previous work but constantly expands its capabilities in order to address new problems.

The company exists at the interface between academia and industry. Although all of its research is applied, there is a sufficient underpinning of theory to satisfy top researchers and senior technical staff who might otherwise prefer academic work.

FINANCIAL HISTORY

The company had only one round of financing. When the founders decided to strike out on their own, they personally provided the initial capitalization that was small. The founders put in an all out effort for this first year. They worked seven days and six nights a week. They drew no salary for the first six months. They met with some former contacts in federal agencies, but largely pounded the pavements for new sources of work. After six months, they had their first contract. After a year, the company was profitable, but just barely. During its second year, the company began to exhibit profit levels, which it maintained through the present. These have allowed the company to grow without any additional financing. The company has had a steady growth profile and no cash flow problems. The only bank loans the company has taken were repaid rapidly.

The founder interviewed was aware of the uniqueness of the company's financial history and attributed its above average productivity per research dollar, to hard work, careful planning, and unusual capabilities in technology and personnel.

SALES AND EMPLOYMENT HISTORY

The company has exhibited a steady annual growth in sales and employment of 30 percent. The company's sales are entirely to the government.

GOVERNMENT INVOLVEMENT

It had been the founders' intention from the outset to seek government contract R & D work exclusively. Although the company had a few industrial contracts its first year, it soon established sole source arrangements for certain types of systems work with the Navy and NASA. The founders succeeded in diversifying and augmenting their sources of government contracts but have remained almost entirely within the various government agencies.

Because much of the company's work is classified defense contracts, the company has been largely unaffected by cutbacks in government funding.

SIGNIFICANT EVENTS AND KEY FACTORS

According to Founder 1, the key factors in the company's success were its unique technology, high productivity and ability to package and market its services. The computational techniques put the company so far ahead of the rest of the field, that it secured many important sole source contracts with government agencies for this work. The management, personnel make-up, and careful planning of the company render it far more productive per R & D dollar than most other firms, enhancing the company's attractiveness to the agencies spending research dollars. A conscious decision was made to work almost exclusively for the government and always as the prime contractor. This avoids a conflict of interest when evaluating new commercial technology for government agencies. Finally, the company was able to translate its unique technology and high productivity into financial success because it could package and market its varied services.

CASE #27

COMPANY DEVELOPMENT AND TECHNOLOGICAL DEVELOPMENT

The company is a leading manufacturer of analytical instruments, principally liquid chromatographs. It was the second successful commercial venture of an inventor-entrepreneur who, from 1947 to 1955, ran a firm that produced infrared gas analysers, which he sold in 19[illegible]. Since 1978, the founder has been running a firm that designs [illegible] business information systems. The founder built the company on a process control refractometer he had been developing as an out-growth of his earlier work in infrared spectrophotometers. The company began producing laboratory scale refractometers to detect the output from liquid chromatography columns. In 1960, a major chemical firm needed a refractometer detector for the gel permeation chromatograph it had been developing. In 1962, the company received exclusive rights to the gel permeation chromatograph which, with the company's refractometer detector, revolutionized the determination of polymer properties. The company also continued its work with liquid chromatographs.

In 1980, the company was acquired by a larger firm in the instrumentation field with different but complementary technology.

FINANCIAL HISTORY

The founder financed the company in 1958 with his savings. Much of this money came from the sale of his first company. Shortly after founding, a major chemical manufacturer became interested in the company's process control refractometer for use with its gel permeation chromatograph. Sales reached $500,000 by 1962. The company needed additional capital to finance this 40 percent annual growth and cover cash flow. In 1962, a venture capital firm made a common stock investment in the company that provided this much needed capital. In 1964, a venture capital firm and a large chemical manufacturer made an additional investment. In 1970, the firm that would buy the company out ten years later made an equity investment. The founder's family retained 45 percent ownership in the company at this time. In 1973, the company went public in response to its investors' demands for liquid stock. The company raised additional capital through two further stock offerings in 1975 and 1977. In 1980, the company became a wholely owned subsidiary of another firm in the bio-medical instrumentation field through a stock transfer.

This firm has far better management resources, so should help alleviate some of the company's management problems associated with growth.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1958	$ 70,000	30	5
1975	$ 17 Million	?	300
1979	$ 70 Million	0	1150

GOVERNMENT INVOLVEMENT

During the company's first three years, 30 percent of its annual sales were government R & D contracts. Afterwards, however, the company suspended all government work. The founder felt that government work entailed far too much paperwork and far too little money to make it worthwhile on a long-term basis. Further, he felt that the staff mindset necessary for success in government work would preclude good commercial development.

SIGNIFICANT EVENTS AND KEY FACTORS

The key factors in the company's success were the founder's entrepreneurial skills, and the corporate decision in 1970 to change management and consolidate its development strategy.

The founder was, and is, a very successful entrepreneur. He has tremendous ability, not simply to design instrumentation, but more importantly, to identify key technological problems and develop innovative solutions that will lead to significant markets. His skills led directly and indirectly to the company's success. The gel permeation chromatograph with the company's refractometer detector analyzed polymer characteristics so much faster and more completely than existing methods, that the product had a large market and slaes from its introduction. Further, the founder's previous entrepreneurial success contributed both the company's basic technology and sufficient starting capital that the founder did not have to seek outside financing until 1962.

By 1970, the company had reached a critical growth point which could not be surpassed solely with technological innovations. In order to grow and survive in increasingly competitive markets, the company needed new management, a clear focus on product development, markets and business plan. The founder recognized these needs and was willing to turn over the company's control to more competent managers, while retaining technical directorship. Many other high technology firms have failed at this point in their histories because a founder, who was a technologist but not a manager, was unwilling to relinquish control of his business.

CASE #26

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company produces water treatment chemicals primarily for the swimming pool industry. It was founded in the late 1950's by a biochemist interested in the control of algae growth in freshwater ponds. The founder tinkered with copper sulfate derivatives as a sideline from his work at a large pharmaceutical firm. When he had developed a marketable product, he left his employer to start his own business. The company remained very small but sales to local swimming pool markets were sufficient to support the founder's continued development of new algicides.

In 1969, the founder sold the company to an insurance salesman seeking a career change. The new owner hoped, with better management, marketing and focused product development, to transform the company from a minimally remunerative hobby into a highly profitable business.

The new owner continued to base the company's work on the copper sulfate technology licensed from the founder. He hired additional technical people to broaden the product line. He also instituted an agressive marketing policy to offset the extremely seasonal sales pattern of a company catering primarily to the swimming pool industry in a northern state. The company's technical staff has been developing chemicals that can control algae growth in rice fields without damaging the rice plants, as well as new products for the recreational vehicle industry. The marketing staff has been developing markets for these new products as well as developing new markets for existing swimming pool algicides in the south and west, where the water treatment season is considerably longer than in the north.

In 1979, ten years after the company was purchased by its second owner, sales reached $3.5 million and employment 65. The company has resolved many management and financial problems and looks forward to continued growth and technological development.

FINANCIAL HISTORY

Information is not available on the original founder's start-up costs. The second owner acquired an almost defunct company and invested about $25,000 during the first year plus an additional $2,000 to buy the patent rights from the estate of the original founder who had died. Soon after he purchased the company, the second owner sold stock to ten outside investors and raised $68,000. Although company sales soon rose, they were rarely sufficient to support rapid company growth or meet cash flow needs.

After his brief stock offering, the new owner financed company growth entirely with loans. In 1973, he secured a $250,000 SBA guaranteed loan from a local bank. Since the SBA prohibited the loan's use for long term capital investment, the owner sought other types of loans, and in 1975, paid off the SBA loan. The owner often meets cash flow problems with short-term borrowing from a bank or with his personal funds.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1968	$ 28,000	15	8
1974	?	?	15
1979	$ 3.5 Million	5	65

GOVERNMENT INVOLVEMENT

The 1973 SBA loan guarantee was critical to the company's continued existence at a time when traditional sources of venture capital were essentially unavailable.

The company's only other contacts with the government are through its efforts to meet EPA toxicity standards and its marketing of algicides to state and local governments. The company has embarked on a costly and time consuming testing program to qualify its chemicals for EPA licenses by which they hope to gain some market exclusivity. Its sales to state and local agencies account for less than 15 percent of its total sales.

SIGNIFICANT EVENTS AND KEY FACTORS

The company's success since 1969 is attributable to its innovative products, agressive marketing program and the availability of debt financing at crucial junctures.

The company has consistently developed new copper sulfate derivatives that are effective algicides in many environments. The company has also succeeded in reducing the general toxicity of its chemicals but increasing their specificity, thereby rendering them both more efficient and ecologically desirable.

The owner sought to break the seasonality of his new business by agressively pursuing year-round markets. The company has developed new applications for its products with stable markets. In addition, it has developed extensive markets for its swimming pool products in the south and west where the swimming season is almost year round.

Finally, the availability of debt financing, notably the SBA guaranteed loan, but also short-term bank loans, helped the company through financial difficulties, thereby enabling it to realize the benefits of its marketing and product development programs.

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company is the producer of a small computer for use in controlling energy usage. This micro-control energy management system first collects information on energy flow and consumption, and then prescribes a program for selected equipment to operate. It is intended to control the operation of heating, ventilating and air-conditioning equipment in medium sized operations. The founder worked for several large corporations before deciding to establish his own company. For about nine months, the founder worked out of the basement of his home doing the necessary development. To assist in this initial work, the founder hired two key technicians and paid them from his own savings. At the end of 1977, the founder requested, and received, aid from a large group of businessman to help in the forming of his new company. In spite of the possibility of providing significant energy savings, the company was unable to secure any help from the federal government in even reviewing the product or trying it out on a federal building to assess its effectiveness. A number of technical improvements have already been accomplished and a domestic unit for households is being developed. The key difficulty seems to be finding more effective ways of penetrating the marketplace. This will require additional financing which is not yet available.

FINANCIAL HISTORY

The initial funding of $18,000 was provided by the founder. Family investors provided $60,000 for 20 percent equity and this permitted the company to obtain a $100,000 bank loan with an SBA guarantee. An additional bank loan of $40,000 was obtained from another bank with a personal guarantee from the founder. When a sales manager was employed during the early stages of the company, an agreement was drawn up to provide 20 percent of equity in lieu of $60,000 of salary. At a later date, five percent

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of the shares of the company were sold to two investors for the sum of $30,000.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	$ DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1978	$ 8,000	0	6
1979	$ 350,000	2	11

GOVERNMENT INVOLVEMENT

Although the government did provide a loan guarantee which the company is actively using to provide $100,000 of the financing, it was not available until other investors had put in a significant amount of capital. It also was insufficient for covering the company's real needs. Additional financing has been raised by the founder and elsewhere, and more is still needed. It is clear that to establish a viable manufacturing business, even after the development work has produced a product in active use, requires a great deal of working capital which is not easy to obtain.

In this particular instance, it is unfortunate that the federal government was unwilling to try the product in one of its facilities. Although it has now proven itself elsewhere, the testing of this device by the federal government to validate claims made (and possibly, a purchase for use in some public buildings) would have greatly eased its earliest problems.

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SIGNIFICANT EVENTS AND KEY FACTORS

The most important factor in this company's continued existence seems to be the founder's willingness to risk his own time and resources to keep it going. In addition to money actually invested, one of the bank loans was obtained by using the founder's home for collateral. The major problem currently faced by the company relates to the difficulty of marketing a capital good item. They are now trying to obtain additional capital to be used to improve the marketing effort. Although they have sixty units functioning well, it is too soon to predict long term survival.

CASE #30

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1968 as a family business to manufacture food processing equipment. Both the technology and initial financing came from a previous family business that included five food franchises and a small food processing equipment plant. Although none of the founders had formal technical training, they developed some innovative equipment in response to food transportation problems among their franchises. The company extended its equipment design to address problems of food storage, cooking and reconstitution. The company has enjoyed reasonable success with annual sales stabilized at $4 million since 1976 and a work force of 105.

FINANCIAL HISTORY

The founders financed the company's establishment in 1968 with capital from the sale of another family business. In 1972, the company underwent major financial restructuring. An estimated $100,000 worth of stock was paid to suppliers as payment for outstanding debts. With the aid of a 90 percent SBA loan guarantee, the company was able to obtain a $250,000 loan. The current line of credit for the company is $750,000. There is a program in the company to buy back the stock exchanged to suppliers. The majority of the stock, however, remains in the hands of the founding family.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	$ DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1968	?	?	?
1975	$ 3 Million	0	95
1979	$ 4 Million	0	105

GOVERNMENT INVOLVEMENT

The company has generally had little contact with the government. Its one involvement, however, was an SBA loan guarantee which was an important factor in the company's financial history.

SIGNIFICANT EVENTS AND KEY FACTORS

The development of the food storage and cooking technology came from a previous family business. It became clear that these devices went far beyond the limited uses for which they were originally developed. After selling the previous family business, the founders concentrated on the production of more efficient storage and cooking devices for use in many food-related industries.

CASE # 31

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was established in 1959 as an engineering consulting firm. The three founders came from the same corporation in the midwest. During the next several years, the founders were trying to develop a product that would be profitable to manufacture. In 1965, it was decided to try to produce a tracer to allow a machine to make copies of complex tools. The idea came from direct knowledge of customer needs. However, it was several years before this tracer was accepted by industry. The company ran into a number of roadblocks before being able to consider large scale production of the tracer.

The company was persuaded to take the device to Europe to be shown in a Department of Commerce sponsored trade show. The tracer was favorably received at this trade show, unlike a similar show held in Chicago, were the tracer was ridiculed for having electric motor power instead of hydraulic power--the popular, new method--and for having a Japanese motor rather than an American motor. As a result of the European trade show, the company found prospects in several countries.

The company serves their European customers from England, with a manufacturing facility in Ireland. In 1979, company products had an 80 percent share of the world market for tracer equipment.

FINANCIAL HISTORY

An initial family investment of $10,000 for 20 percent equity established the company in 1959. In 1961, the company sold 49 percent of their stock for $50,000 to a large manufacturing concern. All additional equity was generated internally from profits and long-term bank loans. In 1979, the company entered into an agreement with the manufacturing concern to buy back the stock sold in 1961.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1959	$ 50,000	5	5
1974	?	?	165
1979	$ 2.7 Million	0	300

GOVERNMENT INVOLVEMENT

The role of the government in the success of this company was very small. However, the help given by the government enabled the company to establish itself in the European market. It was the Department of Commerce that encouraged the company to attend the European trade show. As a direct result of this show, contacts were made in Europe and subsequently sales were made by the company. The only monetary aid given by the government was 80 percent of the trade show booth fee, paid by the Department of Commerce.

SIGNIFICANT EVENTS AND KEY FACTORS

The decision to accept the invitation of the Department of Commerce to attend the European trade show directly resulted in contacts and prospects which led eventually to product sales. The insistence of the company to use traditional electric motor power proved to be fortuitous. The use of this type of motor was accepted over the newer hydraulic power. The founders' strong, realistic company goals established the company as a world leader in the market for their product.

CASE #32

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company is a leading designer and manufacturer of audio and electro-optical systems. The company was established in 1966, when one of the founders, who had a technical background, was working out of his basement. Of the original seven founders, three were instrumental in the development of a computer memory device for a large corporation. The success of this project led to work with another large corporation. Projects for these two corporations continued for several years. However, the technology began to change and the company which produced a component part lost its two major accounts. The company wanted to utilize proprietary technology and be able to sell a total product of its own. The founders had had previous experience writing proposals and doing government R & D contract work. They now actively sought such contracts to pay for the cost of developing a new product. By 1979, 85 percent of the company's annual business was for federal government agencies such as DOD, the Coast Guard and the FAA.

FINANCIAL HISTORY

The initial investment consisted of $25,000 in personal funds from five founders for the total company equity to be used for cash flow. The contracts with the large corporations provided the working capital for the company. In 1969, the company obtained a loan for $150,000 with the aid of a loan guarantee from the SBA. When the company decided to expand the business in 1975, it obtained a large loan of $350,000 to cover the expansion and partially to replace the 1969 loan.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1968	$ 26,000	0	5
1974	?	?	85
1979	$ 3 Million	85	100

GOVERNMENT INVOLVEMENT

The government had no influence in the initial establishment of the company. However, as the private industry funds diminished, the company actively sought, and received, a great deal of government work including money reserved for minority owned firms. The company attributes 85 percent of its annual sales to government contracts. It has also obtained some technical assistance from #406 consultants which was helpful to the company.

SIGNIFICANT EVENTS AND KEY FACTORS

The combined technical backgrounds of the founders led to a successful association with two very large corporations. Several of the founders had experience in performing government contract work before establishing the company. When the commercial business started to decline, the previous knowledge of government contract work of the founders enabled the company to receive large government contracts from several federal agencies. The federal set asides for minority owned businesses clearly made it easier for this firm to obtain government contracts in recent years and government contract work is the majority of the company's current sales. It is not clear why additional commercial work was not obtained. It seems that the company obtained the early commercial work with little effort but failed to keep pace in a rapidly changing market over which it had little control. When sales began to flounder, the first-hand knowledge of government contract sales by the founders made the change in direction the easiest and most cost effective way to acquire the new technology the company needed to survive.

CASE #33

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The founder was on the radiology faculty of a medical college and had been thinking of starting a business for some time. He had been looking for a good product idea, and in 1969, started working on a specific product in his basement to be used as an aid in patient positioning for laser or X-ray treatments. It took over three years, until 1973, to perfect the technology sufficiently to begin real operation of the company. The founder continued to work for the company on the side, with a relative handling the main operations until 1975, when he took over full time management. At that time, he rented space, hired part-time labor and used management assistance help from SCORE, ACE, etc., to get off the ground. Although the company received no contract support from the government to develop the technology, liberal government funding of medical care has made it much easier for hospitals and clinics to purchase this equipment. Sales have grown steadily in recent years, and the company has been profitable since 1975.

The growth of this company is a direct result of a creative technologist's looking at the needs in his own field and developing instrumentation to solve a clearly identified problem. The market need was understood and a commercially viable product to fill that need was always the goal.

FINANCIAL HISTORY

Most of the initial investment was made by the founder using personal time to develop the technology in his basement, plus about $2,000 in out of pocket expenses. The company has never received outside equity financing. The founder loaned $100,000 to the company and recently a $250,000 line of credit has been granted by a local bank.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	$ DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1973	$ 30,000	0	13
1979	$ 1.1 Million	0	30

GOVERNMENT INVOLVEMENT

The government played several different roles in the history of this company, primarily in management assistance and in market support. The current primary user of the company's product is the health care industry in which government funding of both research and services frequently enables institutions to purchase expensive capital equipment that they could not afford otherwise, but which can reduce costs in the long run. Direct sales to the government, e.g., VA hospitals, did not come until after the product was proven in private institutions and had little impact on the company's history.

The founder feels he received key help from SCORE and ACE advisors. Two of the SCORE advisors came with the company in official capacities, one in a managerial role and the other in a financial role. These people were also instrumental in establishing a good relationship with the president of a local bank.

The U.S. Department of Commerce provided assistance in launching international business which is now the fastest growing segment of their market. DOC provided Trade Center facilities in Mexico City in 1979 that are expected to result in significant sales and other overseas shows are planned.

SIGNIFICANT EVENTS AND KEY FACTORS

The most important factor seems to be the thorough knowledge of the marketplace by the founder, and his unswerving drive to build a piece of equipment to fill a known need. Although the founder had little business experience, he was able to rely on effective help from several different government supported programs: **SBA SCORE and ACE programs and the Department of Commerce.**

Although the company is doing well at the moment, it has yet to develop a second market area, and it is beginning to face competition in its initial markets. The current product is covered by patent protection both in the U.S. and overseas, but it is not yet clear how well it will stand up if challenged. The next few years, as the company looks for other applications for its technology in markets not as readily understood, will be critical ones in establishing long-term success for the company.

Mr. MITCHELL. Our next panel will be Mr. Mike McKevitt of the National Federation of Independent Business; Mr. Eric Schellin, National Small Business Association; Mr. Earl Hess, Small Business Council, U.S. Chamber of Commerce; Mr. Phil Friedlander, Small Business Legislative Council; and Mr. Benson P. Lee, Small Business United.

PANEL CONSISTING OF ERIC SCHELLIN; PHIL FRIEDLANDER; EARL H. HESS; BENSON P. LEE; AND JAMES D. "MIKE" McKEVITT

Mr. MITCHELL. Gentlemen, I thank all of you for taking time from your very busy schedules to be here. As indicated earlier we have a lengthy list of witnesses, 19 in all, and others who are seeking to testify today. So if you could keep your testimony as tight as possible so we could avail ourselves of your expertise by putting questions to you.

Mr. McKevitt.

Mr. SCHELLIN. He is outside, Mr. Chairman.

Mr. MITCHELL. Let's start with Mr. Schellin, then.

TESTIMONY OF ERIC SCHELLIN, ON BEHALF OF THE NATIONAL SMALL BUSINESS ASSOCIATION, AND THE NATIONAL COUNCIL FOR INDUSTRIAL INNOVATION

Mr. SCHELLIN. Thank you very much, Mr. Chairman. It is a pleasure to be here today. I will keep my remarks brief.

I have a prepared statement I would like to enter into the record. It will be submitted later today.

Mr. MITCHELL. The prepared statements of all the witnesses today will be submitted for the record.

Mr. SCHELLIN. I am with the National Small Business Association and as its name suggests, it is an association of small businesses throughout the country. Many of our members are vitally interested in this legislation. I am also the immediate past president of the board of this association, and I am also speaking today on behalf of the National Council for Industrial Innovation, of which I am a member of the board.

To make a living I am a patent attorney in private practice, and president of a small company. I am also active in the academic field where I teach a course on technology licensing in a local law school, so I speak from three avenues.

In the following I am going to attempt to provide comments that I hope would not be duplicated by others today. Of course some of the comments will be duplicated when I say that we and the association join the chorus in favor of H.R. 4326.

In order to advance technical innovation, small business must be given the assist found in the salutary legislation. We have all heard lip service that Government agencies will see to it that small businesses will be involved in Government-sponsored R. & D. Yet under any administration, little or no special effort occurs, simply because it is not mandated. When there is a mandate that small business must be involved, the story is different.

The NSF SBIR program that we are all familiar with at this point is a successful program and has resulted in great successes with regard to small business. We are now again seeing the same kind of lip service.

Yet agency after agency has attempted to designate itself as an exception to H.R. 4326. This, if nothing else, demonstrates clearly the need for H.R. 4326. If the aim is, in fact, to increase and encourage innovation, then clearly experience shows small business has been enormously innovative. Furthermore, small business packages innovation for greater acceptability than either big business or the universities.

It has been my own personal experience for this reason that big business, if given the opportunity, will always work with small business, rather than a university. This is no fault of the university. The small business entity is constructed to design and deliver a complete innovation package. The university is set up to deliver the ideas. No innovation is complete until it has been utilized.

The ideas generated of themselves constitute valuable resource materials, however. The very mental steps leading to an invention from which an innovation depends can be most directly found in the minds of small business entrepreneurs. For instance, if an innovator is faced with a problem, the innovator contemplates analogous solutions to similar problems. Invention occurs when the inventor makes the connection between analogous solutions to solve his problem and provides therefrom a new solution.

The ability to make that connection, that leap, separates me from my own clients who are inventors. The solution to the problem becomes a basis for the innovation, a new product perhaps, or a better process. We need individuals who can surface and discern appropriate analogies. The more analogies, the greater the likelihood of discovering a solution.

The university environment is not designed to ripen analogous thinking. To the university researcher, information per se has its own end value. The larger businesses are not adept at analogous thinking because of the intensity of specialization of the individuals. The big business environment is designed to support incremental advances of innovation leading to improved products and improved processes.

Big business serves its role well by providing society with copious quantities of goods. In another light, innovation and convention or pure science and technology can only move forward when the thought that goes into them is applied. Small business does the latter well.

This bill, if passed, will result in new ideas also. Very many innovative small businesses call on university researchers, and thus they too will prosper greatly with the passage of H.R. 4326. It has been witnessed that the application of ideas and innovations drives the development and accumulation of more technological information.

A prime example is the second law of thermodynamics. Until the theory was applied to the steam engine there was no benefit from the research nor did the state of the art move forward. Once steam engines were in use, science proceeded beyond the first theory into new and better opportunities involving applied technology and increased the storehouse of basic knowledge as well.

From the foregoing remarks it should be seen that it is always important to consider advancement in terms of practical application. It must also be remembered that I have not stated that small business can do it all. Contrary, the universities, the larger businesses, small business, and the Government have always been and continue in a symbiotic relationship. This legislation merely assures a place for small business.

[Mr. Schellin's prepared statement follows:]

PREPARED STATEMENT OF ERIC SCHELLIN, ON BEHALF OF THE NATIONAL SMALL BUSINESS ASSOCIATION, AND THE NATIONAL COUNCIL FOR INDUSTRIAL INNOVATION

Mr. Chairman, we appreciate the opportunity to appear before this Subcommittee to comment on H.R. 4326.

The National Small Business Association, as its name suggests, is an association of small businesses throughout the country. Many of the members are vitally interested in this legislation. I am Eric P. Schellin, the immediate past Chairman of the Board of the association. I am also speaking today, on behalf of the National Council of Industrial Innovation of which I am a member of the Board.

To make a living I am a patent attorney in private practice and president of a small company.

I am also active in the academic field as a professor at a local law school where I teach a course on technology licensing.

In my following prepared statement, I have provided comments which I hope and believe will not be duplicative of what the other speakers are covering today. Of course, I will surely be repetitive when I join the chorus to state that we are firmly in favor of H.R. 4326 and decry any attempt to emasculate its provisions by any agency cop-out.

In order to advance technological innovation, small business must be given that assist found in H.R. 4326. We have all heard lip service that Government agencies will see to it that small businesses will be involved in government sponsored R. & D. Yet, under any administration, little or no special effort occurs, simply because it is not mandated. When there is a mandate that small business must be involved, the story is different. The NSF-SBIR program is a mandate. A demonstrably successful program has resulted, as we all know.

We are again seeing the same kind of lip service. Yet, agency after agency has attempted to designate itself as an exception to H.R. 4326. This, if nothing else demonstrates clearly the need for H.R. 4326.

If the aim is in fact to increase and encourage innovation, then clearly experience shows that small business has been enormously innovative. Furthermore, small business packages innovation for greater acceptability than either big business, or the universities. It has been my experience, for this reason, big business, if given the opportunity, will always work with small business rather than a university. This is no fault of the university. The small business entity is designed to design and deliver a complete innovation. The university is set up to deliver the ideas. No innovation is complete until it has been utilized. The ideas generated in of themselves constitute valuable resource materials.

The very mental steps leading to an invention from which an innovation depends can be most frequently found in the minds of small business entrepreneurs. For instance, if an innovator is faced with a problem, the innovator contemplates analogous solutions to similar problems. Invention occurs when the inventor makes the connection between analogous solutions to solve his problem and provides a new solution. The ability to make that connection, that leap, separates me from my clients who are inventors. The solution to the problem becomes the basis for the innovation, a new product, perhaps, or a better process. We need, for innovation, individuals who can surface and discern appropriate analogies. The more analogies, the greater the likelihood of discovering a solution. The university environment is not designed to ripen analogous thinking; to the university researcher information per se has its own end value. The larger businesses are not adept at analogous thinking because of the intensity of specialization of the individuals which thwarts broad scope thinking. The big business environment is designed to support incremental advances of innovation leading to improved products and improved processes, but results infrequently in new products or new processes. Big business serves its role well by providing society with huge quantities of goods.

In another light, innovation and invention, or pure science and technology, can only move forward when the thought that goes into them is applied. Small business does the latter well; this bill if passed, will result in new ideas also. As I know from personal experience, many innovative high technology small businesses call on the expertise of university connected researchers. This linkage will prosper greatly with the passage of H.R. 4326.

It has been witnessed that the application of ideas in innovations drives the development and accumulation of more technological information. An old but prime example is the second law of thermodynamics. Until the theory was applied to the steam engine, there was no benefit from the research, nor did the state of the art move forward. Once steam engines were in use, science proceeded beyond that first abstract theory into new and better opportunities involving applied technology and increased the storehouse of basic knowledge.

From the foregoing remarks it should be seen that it is always important to consider advancement in terms of practical application. It must also be remembered that I have not stated that small business can do it all. Contrary, the universities, the larger businesses, small business, and the government have always been and continue in a symbiotic relationship. This legislation merely assures a place for small business. Unless we keep in mind that this nation needs improved productivity, the current recession may never end.

Mr. MITCHELL. Thank you.

Mr. Friedlander.

TESTIMONY OF PHIL FRIEDLANDER, EXECUTIVE VICE PRESIDENT, NATIONAL TIRE DEALERS AND RETREADERS ASSOCIATION, AND CHAIRMAN, SMALL BUSINESS LEGISLATIVE COUNCIL

Mr. FRIEDLANDER. I am executive vice president of the National Tire Dealers and Retreaders Association, and I appear today as chairman of the Small Business Legislative Council.

The Small Business Legislative Council is a coalition of over 70 national associations representing more than 4 million small business firms.

The Small Business Legislative Council strongly supports legislation which would require all Federal agencies with R. & D. budgets in excess of $100 million to initiate a small business innovation research program for a small portion of their research and development budgets.

Small firms and independent inventors already account for more than one-half of the Nation's major innovations, even though they receive only a small portion of the U.S. R. & D. funds. Small business is the best job generator, competes with larger firms, and is an attractive, rewarding environment to scientists and engineers, and has a record of providing to research and development at substantially lower costs.

Small businesses with 500 or less employees generated 87 percent of all new net jobs in the private sector in a 7-year period according to a study done by Dr. David Birch of M.I.T. Large firms of 5,000 or more employees generated only 3 percent, and medium-size firms, 10 percent.

Two major Government commissions, the Charpie Study in 1966-76 and the Domestic Policy Review on Industrial Innovation in 1978-79 both concluded much more effort should be devoted to assisting the founding and growth of technology-based small firms.

About a year or so ago, and I am trying to use this as a practical example of the kind of things that I think could occur in my own experience, the National Tire Dealers and Retreaders Association put up a small amount of investment money, $25,000, to develop for retreaders a method for use of a computer to decide what size of a curing apparatus would be used for a particular size casing. This would be done in order to assist the retreader in determining whether he had the proper equipment to actually retread the customer's tire.

We gave this $25,000 to two individuals and they used this seed money and have so developed this type of program which is now being made available throughout the United States.

Associations such as NTDRA cannot afford to put this kind of money up on any kind of widespread basis, but some mechanism in the use of R. & D. funds could make a significant change in the ability of small business to develop technically better equipment, as well as providing the consumer with either better protection or making an input into a national problem such as recycling.

For example, an economical non-destructive testing device is needed to discover hidden conditions (such as ply separations) in worn tires that could lead to failure of finished product. Or a new economical curing system for retreaders that would allow greater tolerances in order to reduce equipment investments and increase the number of acceptable casings.

Creativity remains with the entrepreneur, but funding is harder and harder to get. Therefore, it seems logical that the Government should be as supportive of this concept as it has been with other small business set-asides.

Mr. MITCHELL. Thank you, sir.

Dr. Hess.

TESTIMONY OF EARL H. HESS, PRESIDENT, LANCASTER LABORATORIES, INC., LANCASTER, PA., ON BEHALF OF THE SMALL BUSINESS COMMITTEE, U.S. CHAMBER OF COMMERCE, AND THE AMERICAN COUNCIL OF INDEPENDENT LABORATORIES

Mr. HESS. Thank you, Mr. Chairman.

My name is Earl H. Hess. I am president of Lancaster Laboratories, Inc., Lancaster, Pa., a small research, development, and analytical services firm which I founded in 1961. I am a businessman by hobby, I guess you would say, and a chemist in private practice. I am here today representing the U.S. Chamber of Commerce's Small Business Committee, and I will have a statement to introduce for the record from them.

I am also representing the American Council of Independent Laboratories as their Director of Government Relations and have a statement from which I will make some remarks.

I should say that both these statements strongly support the bill that is under consideration now as reported from the Small Business Committee without the add ons and deletions placed on by other committees.

The American Council of Independent Laboratories is an association of science and engineering firms who are essentially engaged in private practices offering high technology professional services of both research and development as well as sophisticated and advanced analytical systems.

What I just heard described to my right, development of new systems for testing tires for example, would be well within the range of capabilities of small firms that are members of our association. I would like to now focus on my own company's track record and speak with some experience as to how small business can be very much involved in the innovation process.

I cannot take the time to go back over 20 years of experience. I can say that I am proud of many of the scientific publications we have produced and patents we have authored, but we probably get the greatest satisfaction of seeing processes on line being carried out because of the work we have done in our laboratory.

This I think is the essence of what we are talking about: innovation. Presently we are very excited about some development work in our laboratory that will apparently give birth to a new chemical specialties firm and we hope to be creating jobs in Pennsylvania and building new plants, or our client will be, in the very near future at a time when that kind of thing is very welcome in our economy.

Unfortunately the services of companies such as our own effectively have been denied to the Federal Government because of the complexities of the procurment process. Most of the work we have done has been in working for the private sector.

I get a little bit upset when I hear this bill referred to as a set-aside as if that is something bad. Research and development services, that is, access to them, have been set aside for big universities and big businesses to the exclusion of small firms throughout all this time. Now it is about time to rectify that situation.

I hope you will take the time to look at one of the examples that I cite in my written testimony regarding a request for proposal.

Mr. MITCHELL. OK; I will.

Mr. HESS. A request for proposal went out back in 1975 from the Food and Drug Administration requesting assistance in developing methods for asbestos analysis in foods. And we were denied that proposal. A large nonprofit got the job.

Two years later after the Government spent $160,000 and accomplished very little, they readvertised the bid and this time they went with us. We were convinced the first time it was because of name recognition rather than actual professional capability. Out of that work came a successful series of experiments that resulted in publications. Interestingly, a spinoff of that was another idea which received funding from the National Science Foundation, Small Business Innovation Grant. Again we were successful.

And the technology we have developed there is now in the public domain and is saving a lot of money for those companies that need to get rapid analyses of asbestos. I think that this is an embodiment of what small business, what this whole business is about. Yet, I say the denial of access really has not been to the detriment of small business as much as it has been a loss to the Federal Government.

I commend your committee for the work that you have done already. I particularly appreciate the bipartisan support I see for this legislation and I can only say that the associations which I represent this morning are very strongly in favor of this legislation and hope all efforts will be made to see that the full house acts on the bill as it was reported out of the Small Business Committee.

Thank you very much.

[Mr. Hess' prepared statement with attachment follows:]

PREPARED STATEMENT OF EARL H. HESS, PRESIDENT, LANCASTER LABORATORIES, INC., LANCASTER, PA., ON BEHALF OF THE SMALL BUSINESS COMMITTEE, U.S. CHAMBER OF COMMERCE, AND THE AMERICAN COUNCIL OF INDEPENDENT LABORATORIES

My name is Earl H. Hess. I am president of Lancaster Laboratories, Inc., Lancaster, Pennsylvania, a small research, development and analytical services firm which I founded in 1961. A one-page scope sheet describing our company's services is attached. Our company has no interest in becoming a manufacturing operation, rather it provides high technology services to other companies (large and small), to private citizens, and to government at various levels. Throughout our company's history our efforts have resulted in a number of patented products and processes. But of greater significance are the new products currently in commercial production, the major process improvements now being utilized commercially, our development of analytical support techniques necessary to new processes, and our provision of analytical support to insure the quality of a variety of manufactured products. Beginning with three persons, we have steadily grown to a staff of about 60, nearly half of whom are degreed professionals, mostly in the fields of chemistry and biology. Since 1978 we have operated a branch laboratory in Waynesboro, Pa. In its 21 year history, our company has never laid off an employee for lack of work. During the last 18 months we have committed about $800,000 to expanded facilities and new equipment.

Although independent laboratories differ in size, in discipline and the mix of R&D vs. analytical support activities, our company is generally typical of the several thousand independent laboratories throughout our nation. The American Council of Independent Laboratories, Inc. (ACIL) which I represent today as its Director of Government Relations, is the professional association of these science and engineering firms with a membership of about 250. In addition to my association with this professional trade group, I also serve in various Chamber of Commerce positions, (member, Small Business Council, U.S. Chamber of Commerce; Chairman, Pennsylvania Small Business Advocacy Council (PASBAC), a division of our State Chamber; and as Vice Chairman, Public Affairs of our local Chamber in Lancaster, Pa.). I am also a member of the Action Council of the National Federation of Independent Business (NFIB), and serve on the Advisory Council of the Pennsylvania Technical Assistance Program (PENNTAP), a model organization dedicated to technology transfer, mainly to small businesses.

Practically all of the studies conducted over the last decade on the subject of innovation conclude that individual inventors and independent small businesses contribute in an extraordinary manner to the technological development of our nation. I am pleased to place my company's record on the line in support of that conclusion. Yet we are aware that in recent years, barriers to the establishment and healthy growth of such firms have developed. A 1979 SBA Office of Advocacy Task Force [1] addressed this problem and offered a number of suggestions aimed at correcting this situation, one of which is the subject of the legislation under discussion today. Innovation was also a subject which received prime attention at the 1980 White House Conference on Small Business.

Given then, that small high technology businesses are the highest generators of innovative products and processes, an obvious question follows: Why have they not been used to some significant extent in the solution of the technical problems faced by our Government? In a few words, because of bureaucratic red tape and the built-in bias against small businesses inherent to the procurement system as it now exists. This is especially unfortunate in current times of extreme budget pressures, since it is so obvious that the Federal Government could get "more for less" if it would learn to harness its small innovative businesses in the solution of R&D problems. If time would permit, I could describe to you a multitude of R&D procurement nightmares which our small company has experienced and which are typical of the experiences of many other entrepreneurial scientists in their small businesses. The net results of these frustrating endeavors is to dull the appetite of such scientists to seek Government-sponsored research, especially those with proven track records, whose services are naturally in demand from the private sector. Thus the real loser in this whole scenario is the Federal Government and ultimately all of us as taxpayers. I would like to describe one experience of ours to illustrate this point.

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[1] "Small Business and Innovation," A Report of an SBA Office of Advocacy Task Force, July 1979.

Under the present system, it is natural that procurement officers avoid small companies because of the absence of national name recognition and the danger of being criticized if the small contractor does not perform well. In 1975 Lancaster Laboratories, Inc., and Structure Probe, Inc., another small independent laboratory, responded with a jointly prepared proposal to an FDA Request for Proposal (RFP) on the Isolation and Detection of Asbestos in Foods and Beverages. When a large nationally known non-profit research institute was awarded the 2-year contract, we asked for a debriefing meeting with FDA officials. It became clear during the discussions that we were at a distinct competitive disadvantage because of our non-profit, tax paying status, but more significantly, because the considerable expertise developed in the analysis of foods and asbestos which our two small laboratories could offer was of less significance in making the award than was a nationally recognized name and prior experience of working with the agency. Frankly, these last two virtues are pretty hard to acquire if someone doesn't provide the first chance.

After two years of work on this project by the big name institute (at a cost to the Government of $160,000) very little progress had been made. Thus, FDA decided to reissue the RFP in 1977, and on this occasion, Structure Probe, Inc. and Lancaster Laboratories, Inc., were awarded the competitive contract, only after extensive efforts to make our expertise better known to FDA. The proof of the pudding, however, was that we successfully developed analytical methods for isolating and detecting asbestos in beverages and foods as requested in the RFP, while the much larger, more revered, non-profit institute failed. Two scientific publications resulted from our work.

An addendum to this story is that our scientists at Lancaster, during the course of the FDA project, conceived a novel idea for a more rapid screening technique for asbestos identification. It involved the search for fluorescent dyes that possessed asbestos-specific binding properties. This research was subsequently funded by the National Science Foundation's Competitive Small Business Innovation Grant System. Again, we were successful in accomplishing the goals of the research project, the fruits of which are in the public domain at a cost to the Government of less than $25,000.

The Small Business Innovation Research Act provides a rare opportunity for legislators. It costs the taxpayer absolutely nothing. In fact it promises major savings in the Government's Research and Development costs. Simultaneously, it makes available to Federal agencies a resource of innovative talent that has proven itself repeatedly in the real world where survival is dependent upon innovative excellence.

I am aware that H.R. 4326 has been labelled by some of its opponents as a "set aside," or in more derogatory terms, a "pork barrel for a special interest group." It is indeed unfortunate that legislation should be necessary to force upon Federal agencies the exercise of simple common sense with respect to the utilization of the resources of small R&D firms. But, be assured, that we who represent that community have tried every other method imaginable, and it hasn't worked! True, the mandate of this legislation will force a new discipline upon Federal agencies. But, after R&D procurement policies have been simplified so as to permit access to the market by small R&D firms, and after procurement personnel have learned how to find and utilize small, innovative R&D capabilities within that framework, then it will not be long until the fuller utilization of small firms will be spontaneous. For we will have had a chance to prove ourselves.

We appreciate the support of those members of the House who have stepped forth to cosponsor this legislation, as well as those who have helped to guide it through a maze of committee deliberations. We would commend them for their perception of the severity of this problem and for the courage and stamina to stick with the effort when confronted with the powerful lobbying efforts of narrow, self-interest groups. We also commend the Senate and the Administration for their support. Now we respectfully request that the entire House pass H.R. 4326 in the unblemished form in which it has emerged from the Small Business Committee.

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SOLID WASTES
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CONSULTATION

Food Technology and Microbiology, Quality Assurance, Sanitation, Nutrition, Waste Treatability and Disposal, Regulatory Agency Compliance, Polymer Science and Technology, Fiber and Textile Science and Technology, Computer Software for Laboratory Management, Least Cost Formulation of Feeds.

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CERTIFICATIONS AND REGISTRATIONS

Water Analysis (EPA #38-037) Pennsylvania Dept. of Agriculture and USPHS–Dairy Product Testing and Farm Inspection, Food and Drug Administration Reg. #25-13291 U.S. Dept. of Agriculture Certification—Meat Analysis (#4282), American Association for Laboratory Accreditation (#1, Chemistry)
Bureau of Mines Small Operator Assistance Program

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MEMBERSHIPS

(Laboratory or Staff)

American Council of Independent Laboratories, Inc., American Association of Small Research Companies, Pennsylvania Manufacturing Confectioners' Association (Associate Member), Lancaster Chamber of Commerce & Industry, Better Business Bureau, Institute of Food Technologists, American Chemical Society, American Association for the Advancement of Science, American Society for Testing and Materials, American Oil Chemists Society, New York Academy of Sciences, Association of Official Analytical Chemists, Pennsylvania Approved Dairy Laboratory Directors Association, American Water Works Association, National Federation of Independent Businesses, American Association for Laboratory Accreditation, Pennsylvania Chamber of Commerce, U.S. Chamber of Commerce, American Industrial Hygiene Association, American Public Health Association, Water Pollution Control Federation.

PREPARED STATEMENT OF THE U.S. CHAMBER OF COMMERCE

On behalf of the more than 240,000 members of the Chamber of Commerce of the United States, I wish to express our views on H.R. 4326, the Small Business Innovation Act.

The Chamber of Commerce of the United States is the largest federation of business and professional organizations in the world, and is the principal spokesman for the American business community. The Chamber represents more than 240,000 members, of which more than 235,000 are business firms, more than 2,800 are state and local chambers of commerce, and more than 1,300 are trade and professional associations.

More than 90 percent of the Chamber's members are small business firms having fewer than 100 employees, yet virtually all of the nation's largest industrial and business concerns are also active members. We are particularly cognizant of the problems of smaller businesses, as well as issues facing the business community at large.

Because small business dominates our membership, we have a vital stake in seeing that it receives a fair share of the federal research and development monies.

Innovation is an essential ingredient for economic and social growth. Innovations create new and better jobs, reduce production costs and prices, increase foreign sales, and increase real personal income so that our citizens can finance major advancements in the quality of life such as better education, improved health care, and more leisure and recreation.

Small firms and independent inventors already account for more than one-half of the nation's major innovations even though they receive only 2 to 4 percent of the Federal R. & D. funds. Small business also is the best job generator, provides business competition, and is an attractive rewarding environment to scientists and engineers. Small business also does R. & D. at substantially lower cost.

The Chamber's position is that Federal agencies engaged in research and development should expend an increased and appropriate amount of their research and development budgets to small business in order to foster and encourage further innovation.

As you know, the Chamber has not supported "set-aside" programs in the past. However, we do not view establishment of a Small Business Innovation Research (SBIR) program within a federal agency as a "set-aside." Unlike set-aside programs, the SBIR program is competitive. That means firms will respond to agency solicitations and awards will be made based on the quality of the proposals submitted. Agencies are expected to review proposals carefully and make awards based on quality and agency mission needs.

The contribution to our economy and to government agencies implementing this Act would be far greater than the modest research and development dollars involved. We urge the House to act quickly and adopt H.R. 4326 as reported by your committee.

Mr. MITCHELL. Thank you, sir.

Mr. Lee.

TESTIMONY OF BENSON P. LEE, PRESIDENT, DATALOGICS, INC., CLEVELAND, OHIO, ON BEHALF OF SMALL BUSINESS UNITED

Mr. LEE. Mr. Chairman, I appreciate the opportunity to be here today. In response to your request to make it brief, I can say that my statement is brief but my introduction is a bit lengthy, so I will try to read fast.

My name is Benson Lee. I am a small businessman specializing in health care/technology transfer. I am also an entrepreneur. I am president and owner of Datalogics, Inc., a remote computing services company based in Cleveland, Ohio; president and a principal in American Medical Systems, a technology management company which is commercializing a patented device which heals bones using electricity.

As part of our product development strategy, we have entered into an innovative basic research program with the University of Pennsylvania Medical School where we provide funding to them to serve as our primary research facility in this highly specialized field. I am a director and principal in the Instrument Development Corp., a New Jersey company which is involved in technology transfer and instrument development for otolaryngology and noise control. Otolaryngology is the ear doctor, if you will.

I am the sole outside director of the Cornell Research Foundation which holds the responsibility for commercializing all patents owned by/or assigned to Cornell University. My primary responsibility is to advise and assist the foundation at the policy level to facilitate joint partnerships between private enterprise and the university.

Finally, I am proud to be a member of Cleveland's Council of Smaller Enterprises, whose 4,000 member companies make it the largest local small business group in the United States.

I am a graduate of Cornell University's School of Electrical Engineering and have done graduate work in both business and physiology at New York University. I spent 7 years in industry with IBM Corp. and Westinghouse Electric Co. where my responsibilities were to identify productized technological solutions to problems in health care delivery.

I left industry in 1970 when I went into business for myself.

H.R. 4326 first came to my attention as a result of the publicity given to the university lobby opposing its passage. Since I have long been an advocate of partnerships between the university and small business, I was surprised. As I learned more about the status of the bill, it became clear that the two are not adversaries at all, but indeed are competing for vitally needed funding.

I took the opportunity to speak with some of my colleagues at Cornell who serve as directors on the foundation and it is clear to me that they are not against small business. In fact, many share their optimism about the important role small business plays in the process of commercializing university-based technology. I regret the unfortunate positioning of these two important prime movers of American technology, and I continue to feel strongly for the need for coalescing the two. But this is not why I am here today.

I am here in support of the Small Business Innovation Research Act, H.R. 4326, because it is a fundamental step toward meeting the nonavailability of capital problem faced by every high technology startup company. Generally speaking, there are very few dollars available for funding the type of feasibility studies which precedes the birth of a high technology company.

This is the stage where the technology is somewhere between a gleam in the eye and a working prototype.

Mr. MITCHELL We have lost our microphone power again. I will have to indicate that Secretary Haig had a meeting in this room.

Since that time, we have had all sorts of difficulty with our equipment.

I think you are being heard now.

Mr. LEE. It is part dream, part vision, still in its conceptual stage, but supported by years of dedicated scientific study. Since the prototype cannot be measured or costed and cannot be evaluated because it does not exist yet and management cannot afford to devote full time, the world of venture capital will not touch it with a 10-foot pole. I have seen many good ideas fail to get off the ground because of their inability to make the right financial connection. These type of dollars are described by some as feasibility; I jokingly call them throwaway dollars.

The reason is because the risks are very high at this stage. Even after a concept has been proven, it can still collapse because of its business. Certainly, every idea will not be a winner. But then, we only need one or two to make it worthwhile.

The concept behind the Innovation Act to parallel the three-step approach used in the National Science Foundation, NSF, program makes excellent sense to me because it combines the open mind of the scientist of nothing ventured, nothing gained with the practical business incentives of equity. In areas like Cleveland, Ohio, there is an abundance of money. But these dollars are all directed toward funding projects that, behind closed doors, we could say go clank, squeak, or boing.

Very little is available for high technology. Funding from this act could be better described as being sent from heaven. Ironically, Cleveland can claim worldwide stature in the abundance and quality of its medical research facilities, yet Cleveland has been a failure in its ability to develop the financial infrastructure needed to transfer technology from its institutions to the marketplace. How many other logjams are there across the country.

A second major reason I support the bill is because I see it as a doorway to much greater participation between universities and small businesses. In the rush to replace Federal dollars, universities have taken a very traditional view of business as being the large corporations. Small business has been largely ignored.

This is a mistake because, in general, big business and industry typically conduct their research in-house and only fund outside research when they have to. The exact opposite is true for small businesses. Very few have enough capital to pay for the facilities or to pay for a research team. They need the large research institute as much as the institutes need to move an idea from the laboratory to the marketplace. I am in favor of anything which encourages this type of participation. We will all win in the long run.

Thank you.

Mr. MITCHELL. Thank you, sir.

TESTIMONY OF JAMES D. "MIKE" McKEVITT, DIRECTOR OF FEDERAL LEGISLATION, NATIONAL FEDERATION OF INDEPENDENT BUSINESS

Mr. McKEVITT. Mr. Lee maybe came up with a new innovation. That is to put a timer on the microphones and move the hearings along.

In the interest of time, I would like to submit my statement for the record and reference a study of major innovations between 1953 and 1973 produced by NSF and published in Science Indicators 1976, found that:

One, small firms produced about 24 times as many innovations as large firms and almost four times as many as medium-sized firms per R. & D. dollar expended;

Small firms had a ratio of innovations to R. & D. employment four times greater than large firms;

The total number of major innovations by small firms was greater than by large or medium-sized firms, and;

The total cost per scientist and engineer was almost twice as great in firms of over 1,000 employees as it was in firms of less than 1,000 employees.

I think these facts speak for themselves.

Mr. Chairman, NFIB strongly supports this legislation, always has and will in the future. We think it is not just the direct benefit on the membership which will be minimal. We think it is good for the country and therefore we support it.

[Mr. McKevitt's prepared statement follows:]

PREPARED STATEMENT OF JAMES D. "MIKE" MCKEVITT, DIRECTOR OF FEDERAL LEGISLATION, NATIONAL FEDERATION OF INDEPENDENT BUSINESS

Mr. Chairman, the National Federation of Independent Business (NFIB), which represents in excess of a half million small and independent businesses across the nation, welcomes the opportunity to lend our support to a program which promises to be of significant benefit both to the small business community and to our nation—the Small Business Innovation Research Program as envisioned in H.R. 4326.

In the long course of deliberations on this program, one appalling fact has been made evident: there is an overwhelming lack of understanding about the vital role small businesses play in innovation. No one, of course, argues the importance of innovation as a major factor in our country's long-term economic growth. Innovation creates new products, processes, and services that fuel productivity increases, resulting in significant increases in wealth per capita and a higher quality of life for our citizens. Equally important, innovation creates jobs and stems inflation.

Yet, opponents of this bill have steadfastly refused to concede small business' role in the innovation area, despite results of numerous studies indicating that no other sector of the economy has made more contributions to technological innovation than small business. For example, a study of major innovations between 1953–1973, produced by the National Science Foundation and published in "Science Indicators 1976," found that:

Small firms produced about 24 times as many major innovations as large firms and almost four times as many as medium-sized firms per R. & D. dollar expended.

Small firms had a ratio of innovations to R. & D. employment four times greater than large firms.

The total number of major innovations by small firms was greater than by large or medium-sized firms.

The total cost per scientist and engineer was almost twice as great in firms of over 1,000 employees as it was in firms of less than 1,000 employees.

Small business' tremendous innovative abilities are all the more extraordinary, given that these firms receive less than 4.1 percent of the Federal Government's total R. & D. budget and only 8.1 percent of the R. & D. contract awards. When we consider the significant contributions to technological innovation made by small firms with virtually no government support, imagine what benefits could be derived if government resources were channeled to the one sector of the economy with the proven ability to use such resources both efficiently and effectively.

Rather than take issue with each item in the litany of complaints put forth by the bill's detractors, NFIB asks that two ideas be kept in mind. First, any new idea takes time to get used to; if the idea holds the promise of markedly changing the status quo, the resultant furor is all the more vociferous. Second, those who believe they have the most to lose will kick the hardest. Hence the criticisms both Federal agencies—reluctant to change the establishment mode of operations and decidedly hostile to being forced to deal with a new set of potential contractors—and from the universities—which have been protected from competition for so long while enjoying such a large chunk of the Federal R. & D. dollar.

Enactment of H.R. 4326 will accomplish several things. A formal mechanism—the Small Business Innovation Research program—will be established to support the R. & D. efforts of small firms. Many of the impediments to small business participation that currently exist in the procurement system will be eliminated in the R. & D. area. The SBIR program brings a healthy infusion of competition to the Federal R. & D. contract process, where the normal conduct of business has been noncompetitive awards (70 percent of R. & D. contracts are awarded through negotiation). While the SBIR program is restricted to small business, those businesses must compete with each other for contract awards. The competitive awarding process will thereby promote more efficient allocation of Federal resources, insuring that contracts are awarded to the most capable firms at the lowest prices.

Conversely, enactment of H.R. 4326 will not set in motion another 8(a) program. The SBIR program is not a business development program; awards will be made to small businesses which are proven performers, and will be based on the quality of submitted proposals within a competitive system. The SBIR is a program which will provide easy access to Federal R. & D. funds for firms with resources too limited to mount a government marketing effort equal to that of big business or university contractors. The program removes another impediment by granting authorization to agencies to award contracts to "for-profit" entities. The program facilitates effective technology transfer, creating an important linkage between Federal R. & D. and innovation by bringing together the two essential component parts for success: the Federal R. & D. dollar and the most innovative sector of the economy.

Mr. **MITCHELL**. Thank you, sir.

I would like to make a request of you gentlemen if you have the time. I have questions and I know other members have. Although this hearing was called for the small business community to rebut some of the criticisms that have been launched against this legislation, Congressman McCloskey, who does oppose the legislation asked time to speak. He is in a markup. I would like, if you can spare the time, could we put him on for his testimony and then come back to you for questions?

Is that agreeable?

PANEL CHORUS. Fine.

Mr. **MITCHELL**. Fine.

Congressman McCloskey.

TESTIMONY OF HON. PAUL N. McCLOSKEY, JR., A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CALIFORNIA

Mr. **McCLOSKEY**. Thank you, Mr. Chairman.

Mr. **MITCHELL**. We have a copy of your statement.

Mr. **McCLOSKEY**. Mr. Chairman, knowing the time constraints of the committee, I will not read the statement in full. I would like to add to the committee's thinking on this.

I represent "Silicon Valley," which I think is probably the greatest center of high technology organizations in the country. It also includes of course Stanford and Santa Clara Universities, so my bias I think will be apparent to the committee.

May I ask that my testimony be included in the record at this point?

Mr. **MITCHELL**. Without objection.

[Mr. McCloskey's prepared statement follows:]

PREPARED STATEMENT OF HON. PAUL N. MCCLOSKEY, JR., A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CALIFORNIA

Mr. Chairman, I appreciate this opportunity to explain why I oppose the Small Business Innovation Act, H.R. 4326 and its Senate equivalent, S. 881.

H.R. 4326, the bill before you today, would mandate federal agencies to set aside 3 percent more of their research and development funds for small businesses.

A worthwhile purpose? Certainly. All of us would like to see small businesses get their fair share of government contracts. But is one more new law necessary in order to achieve this praiseworthy result?

The Congressional Budget Office has estimated that the new law will cost the federal government $193 million through 1986, or an average of $38 million per year. The bill does not authorize any additional funds, however, leaving it to the affected agencies either to add their administrative expenses to their budget requests, or to compensate for these costs by cutting back on the current level of research and development.

I have appended to my testimony, as exhibit A, the five major steps which federal agencies will be required to take to administer the proposed law, and the implications thereof.

If the proposed bill is enacted into law, it has been estimated that the government will be required to fund 30,000 proposals per year to small companies. This represents 30 times the number of investments made by the entire venture capital industry, and would provide nearly one federal R. & D. contract or grant to every R. & D. scientist or engineer in a small business. Each proposal must be verified, monitored and enforced through the five steps outlined in exhibit A.

At a time when we are trying to cut the size and cost of government, there seems little reason to interpose one more set of government regulations and personnel into a system of free enterprise which is already doing better than most.

But, argue the bill's proponents, small businesses don't have access to sufficient capital to compete with the larger companies.

This may have been true in 1977, before passage of the Steiger Amendment reducing the maximum capital gains rate from 49 percent to 28 percent. In 1977, only $39 million in new capital was invested in venture capital companies, the chief source of funding for young companies.

With passage of the Steiger Amendment in 1978, and subsequent tax changes in 1981, however, such as the R. & D. tax credit, further capital gains rate reduction and the incentive stock option, 1981 investment in venture capital companies has skyrocketed to over $1.2 billion, and public investment in small companies to $1.8 billion.

High risk, high potential, small scientific research companies are now highly attractive to investors * * * these companies represent a greater chance for high capital returns than nearly any other kind of company in America.

Are small companies receiving their fair share of government research and development funds, however?

According to the data from the Federal Procurement Data Center, an arm of OMB, and the National Science Foundation, small businesses employ 5.5 percent of the R. & D. scientists and engineers in the private sector, and already receive 6.8 percent of federal contract dollars awarded for private research. Thus, the government's R. & D. investment in small companies appears to be in line with the capacity of small companies to absorb these funds.

I have appended to my testimony, as exhibit B, a letter written by the General Counsel of the National Science Foundation last June to OMB, but I will quote briefly from that letter because the small business program at NSF is the model on which both H.R. 4326 and S. 881, are based. In that June 25 letter, the NSF General Counsel wrote:

". . . the proposed permanent legislative extension of the NSF's Small Business Innovation Research Program in its present experimental form across the Government without budget scrutiny seems very unwise. . . .

"NSF is pleased with the program, but we still have a great deal to learn about its real impact, which will depend considerably on success in phase III. Still less has it been demonstrated that this experimental $4–$5 million program at NSF can be fruitfully expanded into a $300–$400 million program across the Government. We doubt that the capacity for so rapid an expansion exists."

This last point is significant. The proposed legislation would expand NSF's set-aside program into a governmentwide program by a 63-fold increase in the Senate bill (from $5 million in the NSF program to $314 million, if a 1 percent set-aside is adopted, excluding in-house research), and by a 240-fold increase in the House bill (from $5 million in the NSF program to $1.2 billion, if a 3 percent set-aside is adopted) . . . all this based on data which is complete for only one year of NSF's pilot program.[1]

By way of comparison, the $1.2 billion program envisioned by the House bill would be equivalent to the amount of investment made in young companies by the entire venture capital industry in 1981. Such a massive increase in government funding would seem to justify more than one year's data.

In sum, Mr. Chairman, your committee has before you today a new Affirmative Action program for the healthiest and most competitive companies in the U.S. economy. The largest association of these small, high technology companies—the American Electronics Association, whose membership is predominantly "small" business within the meaning of this bill—opposes the bill.

Maybe these successful companies have achieved their successes precisely because they have not relied on government to sustain them. After all, it is not the role of government to sustain the free enterprise system, but rather it is the free enterprise system which sustains government.

Let's allow the free market to operate without this governmental intrusion, and the government could save $38 million each year as a result.

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[1] NSF's set-aside program was established in 1977 and, as it is a three-phase program, only 1977's data is available on all three phases.

EXHIBIT A

Steps In The Acquisition Process Under SBIR - Implications Thereto:

1. Establishment of SBIR Program
   - o Extensive Agency coordination to create framework for SBIR Program including assignment of responsibilities and integration of the program into the budgeting/funding/acquisition process. (Duplicates all existing programs designed to enhance small business participation in the acquisition process.)
   - o Creation of control and processing infrastructure to facilitate SBIR Program implementation. Includes creating SBIR-unique computer programs to document receipt of proposals, status of technical evaluations, notifications of review results, contract award, funds accountability, and contract closeout activities. The distinction of the SBIR Program rejection integration into existing mechanisms.
   - o Development of management control devices to report SBIR Program status, monitor funding commitments to insure specific expenditures are achieved, etc. (Dilutes management attention from total R&D management objectives.)

2. Development of R&D Program Plans
   - o In addition to the critical task of identifying new R&D initiatives to support Agency mission objectives, the process will be expanded to tailor R&D tasks to SBIR Program goals. This will involve the likely reduction of individual R&D initiatives into segmented parts which, based upon extensive market research, will optimize small business participation and interest in SBIR proposal activities.
   - o The segmenting of individual R&D initiatives will delay the payoff of research by creating a disjointed approach where the Government Agency assumes responsibility for program integration and control.
   - o Further, such a non-integrated approach tends to eliminate the benefits of synergetic impact by creating the potential for one element or task to set the pace for all remaining elements; thus, one segment which encounter technical barriers will delay the satisfactory completion of the total project. The very nature of R&D precludes the effective integration of multiple imputs from various sources which have no contractual linkage or commitment.
   - o In the development of Agency R&D budgets, the SBIR Program must be viewed as an adjunct since it depends upon the interest expressed by small business firms to participate. In the event targeted areas of SBIR R&D research are not matched by aggressive participation by the small business community, there is the potential that up to 3% of the overall budget may be unpriortized to meaningful R&D initiatives or, at a minimum, represent a commitment to lower priority efforts where a documented, proven cadre of technology based firms may not be known to exist.
   - o In short, SBIR firms will be dependent upon the reserved status of funds to insure their participation in the R&D process. To argue contrary would be to tanamount to admission that there is no basis for the SBIR Program. Agency managers cannot rely upon SBIR to provide mainline high technology R&D contractors....it would

be shortsighted to deny the availability of large firms in those areas of R&D where principal priorities reside.

- The difficulty in making a predetermination at the outset of the annual R&D Program Plan as to what specific elements of inquiry are most suitable to small business participation presents a substantial problem for an Agency. Once the solicitation brochure is issued to industry, the individual R&D topics will have been established; in the event the interest of SBIR firms does not materialize, an entire year may have been lost in pursuing priority R&D inquiries.
- Current legislation is designed to eliminate year-end concentration of contracting. This could easily impair the responsiveness of SBIR by forcing early decisions on what proposals to accept even before the full range of SBIR submissions is received. Therefore, it would be inadvisable to delay priority R&D efforts until the final quarter of the fiscal year and run the very real risk of exceeding funding limitations of that quarters----the result being a major loss of opportunity for legitimate research and a failure to achieve SBIR goals.

3. The SBIR Solicitation Brochure

- Certain Agencies such as the Department of Defense are unable to fully utilize grant programs and must rely upon contracting (and its many administrative safeguards) to implement the SBIR Program. This is critical to the SBIR because of the need to adequately publicize the specific areas of R&D targeted topics. Development of a SBIR Brochure is duplicative of existing mechanisms which publicize R&D areas of interest---and which are designed to foster increased participation in R&D acquisitions for firms of all sizes.
- The SBIR is in duplication with the existing substantial unsolicited proposal programs which have been instituted to seek innovated solutions to unique requirements. No credit is given to Agency goals and objectives in support of small and small disadvantaged businesses from SBIR participation. Thus, the SBIR effort is counterproductive to the unsolicited proposal approach which has served the optimum interests of small firms over the years.
- The SBIR Solicitation Brochure will be designed for specific proposal submission periods, establishing equity for all interested firms. It is the principle of equity which demands all proposals submitted under SBIR receive consistent administrative processing, technical evaluation and documented assessment. It is equity which, under SBIR places a major burden of documented evaluation upon the contracting and technical communities of the Agencies. Protests to the GAO and other non-legal remedies would be available to dissatisfied SBIR participants and could prolong the evaluation process. Further, special financing arrangements, inconsistent with standard R&D payment arrangements, are imposed under SBIR to ease cash flow impact upon the small firms participating; while these may represent prudent financial arrangements given the size and obligations of the firms, it again introduces the non-standard aspects of the program and forces non-standard administration.
- There is the need to establish inter-Agency coordination to eliminate

the potential of overlapping and redundant proposals. This adds to the pre-award phase of the SBIR Program and insure the Solicitation Brochure has been fully coordinated prior to publication; again a non-standard operation.

4. The Mechanism for SBIR Administration

- o A separate receiving, processing and administrative monitoring procedure must be established for SBIR. As a separate program, the controls are duplicative of existing mechanisms, require added computer programming, and workload.
- o Proposals received are transmitted to various labs and offices for complete technical assessment. Given the equity implications, these indepth evaluations cannot easily dismiss the uninformed or idle interest proposals. This tends to dilute available personpower and detracts from higher priority R&D assessments. This is a particularly significant factor given the time constraints imposed to implement the SBIR Program within the times specified in the SBIR Solicitation Brochure.
- o Small businesses, unfamiliar with Government acquisition practices, make routine inquiries into the status of their proposals. These inquiries (phone or correspondence) command attention and further dilute available Government resources without productive benefit. Additionally, unsuccessful firms routinely request a debriefing of the assessment results; under normal procedures the demands are less based upon the institutionalized system well understood by all.
- o Small firms participating in SBIR often have difficulty in retaining the technical expertise which led to submission of a valid proposal; the financial pressures upon these small firms, the delays associated with the evaluation process, and the nation-wide demand for top notch experts often results in a firm's proposal being accepted but in the long term not awarded because of significant changes in the company's organic capacity over time.
- o Because awards are made almost within the same time period, it imposes a major burden upon the contracting offices, auditors and contract administrators. During this period of time, other higher priority R&D initiatives suffer from attention loss --- a situation inconsistent with matching priority concern and funding with the surveillence task.
- o SBIR requires periodic submission of reports detailing the inprocess status of the research effort. These are more often geared to enhance the cash flow of the SBIR participants than in reflecting a systematic optimized report on progress; this non-standard operation adds to the burden of program implementation and monitoring.
- o Because the reserve funds implications of the program, added management surveillance can be anticipated to insure R&D funds are not lost to oversight. The reporting process, including disbursements and anticipated expenditures places a burden inconsistent with the 1-3% SBIR commitment.
- o There is the potential that the full reserve funds will be committed even for marginal research efforts to avoid the loss of appropriations

in the next fiscal year. The logic of this expenditure pattern would prevail since in the next year the reduction would most significantly impact the non-SBIR funding reserve. An condition which provides an incentive to contract using appropriated funds in lower priority R&D efforts is counterproductive to sound management or to the prudent use of public funds.

5. The Contract Performance Period

- o SBIR, to the extent research tasks are segmented to accommodate small firms, adds to the volume of contracts and the workload associated with contract administration. This includes accounting and finance support, contract administrators and contract closeout operations.
- o If SBIR firms have undertaken significant research initiatives, any failure to achieve progress may slow or adversely impact other related R&D efforts. Given the early development of next year R&D Program Plans, it is possible that delays in progress could result in missed research opportunities in the subsequent year or in a major repriority of R&D objectives.
- o SBIR is not consistent with major subcontracting opportunities by top notch small businesses. By encouraging prime contract awards, SBIR creates an anti-subcontracting bias and could deny the linkage of large with small in teaming arrangements which have mutual advantage. Subcontracting can be profitable to small firms, provide a solid awareness of the Federal acquisition process, and lead to evolutionary growth based upon a proven record of performance. On the other hand, improper and inadvisable forcing action to the small business community pushing prime contractor status can be counterproductive to the long term growth position and posture by denying linkage to key segments of American industry where technical transfusion and, even more important, management transfusion can be achieved. Experience breeds the capability for expansion; the SBIR Program does not foster that potential; rather, it tends to exploit the specific expertise of small firms without providing the basis for further growth of shared experiences.

Summary

- o The SBIR is a well intentioned initiative that is not in the long term interest of small businesses nor does it provide for prioritized expenditure of public funds consistent with need.
- o The SBIR Program is a costly layered effort with duplicates existing programs in support of small businesses. It creates the potential for fraud and abuse by offering the opportunity for large businesses to use small firms as "front firms" to capture a substantial portion of Agency R&D funds.
- o SBIR encourages full expenditure of reserved funds to prevent erosion of outyear appropriations regardless of the research benefits to be achieved. The reserved funds are geared to total R&D appropriations and not to the amount of funds available for new initiatives; thus, there is the subtle but prevailing discounting of ongoing R&D efforts whose funding will be artificially restricted.

EXHIBIT B

NATIONAL SCIENCE FOUNDATION
WASHINGTON D C 20550

nsf

OFFICE OF THE
GENERAL COUNSEL

June 25, 1981

Mr. James M. Frey
Assistant Director for
Legislative Reference
Office of Management and Budget
Washington, D.C. 20503

Dear Mr. Frey:

You have asked for our views on the proposed report by the Small Business Administration on S.881. Because of timing we provided some comments to Mr. William Maxwell over the phone earlier today. In general we do not concur with SBA's support for the enactment of the bill. Although we have not been asked for comments on the bill itself, some explantion of our reservations will help explain why we disagree with SBA.

The bill does relate to an apparently real problem. A very plausible case has been made that small businesses are at an unwarranted disadvantage in competing for Government grants or contracts. But the proposed permanent legislative extension of the NSF's Small Business Innovation Research Program in its present experimental form across the Government without budget scrutiny seems very unwise. And the proposed expansion of the mechanisms of P.L. 95-507 to ensnare and complicate the most basic missions of the various research agencies, including the NSF in particular, would be unacceptable. It would also contravene the Administration's emphases on reduced regulation and reduced red tape.

The present three-phase format of NSF's Small Business Innovation Research program is not a magic formula; it may be changed or there may be other variations that offer as much or more potential for benefits to all parties. Further, though there are success stories from SBIR grantees, it is too early to claim confidently that the concept is a success. Indications are positive at present, but we know of no systematic data to warrant extending the program throughout Government. NSF has to date issued four SBIR solicitations. Only a few projects from the first issuance have reached Phase III. NSF is pleased with the program, but we still have a great deal to learn about its real impact, which will depend considerably on success in Phase III. Still less has it been demonstrated that this experimental $4-$5 million program at NSF can be fruitfully expanded into a $300-$400 million program across the Government. We doubt that the capacity for so rapid an expansion exists.

The bill would also superimpose the judgment of a single interest committee of Congress across all other Executive Branch and congressional legislative committee decisions about resource allocation for research. It would establish a special class of claimants. (Since it is already cast in the mold of P.L. 95-507, it is likely that the initial small business focus will at some point have added to it provisions for minorities, women, the handicapped, and perhaps the socially disadvantaged.) In NSF's case the authorization committees have, for the past six fiscal years, considered the role of small business in relation to NSF research resources and programs and have determined a level and the research resources they consider appropriate for such special emphasis. Other authorizing committees could do the same for their agencies. The process would take longer, but it would be a much sounder approach involving detailed consideration of an agency's programs and missions. Undifferentiated assessments against research accounts can assume some strange proportions, so that an overall assessment of 1% may result in 5 to 10 percent in some fields or programs because any set-aside is infeasible in others.

The proposed set-asides would effectively create a sizeable new program without providing any new funds, instead diverting funds from existing programs. We believe OMB should resist creation of such new programs outside the discipline of the normal budget process in either the executive or legislative branches. Certainly it should do so when the new program would be at the $300 million level.

SBA has also specifically suggested revising Section 4 of the bill with respect to Section 9(h)of the Small Business Act so that each agency's goals would be established with input from SBA. We also disagree with that suggestion. Such coordination will unnecessarily complicate the operation of programs that inherently require flexibility. Individual agencies should be able to determine their own goals on the basis of their specialized knowledge and expertise in the areas of research in which they are involved. As SBA points out, the "goaling" requirement may duplicate the goal-setting requirements of Section 15(g) of the Small Business Act. In the alternative, they would recomend deleting the goaling requirement, and we would agree with that suggestion.

We could supply a number of comments on specific provisions of S.881 should you wish. Thank you for the opportunity to comment.

Sincerely yours,

Charles H. Herz

Charles H. Herz
General Counsel

Mr. **McCloskey**. If I can add to the testimony, as the six committees of jurisdiction have looked at this bill, particularly Armed Services and Science and Technology of the committees, and have looked at——

Mr. **Bedell**. You knew we were going to do this to you, did you not? [Laughter.]

Mr. **Mitchell**. Will you please continue. Mr. McCloskey, without benefit of the microphone. [Laughter.]

Mr. **McCloskey**. I knew you would.

I think that first you want to look at two points. Nobody questions that this bill is not going to cost an average of $38 million a year. So out of the $44 billion we assign for research, you are going to take out $38 million for the administration. And I would like to add to your thinking my own experience.

Before I came to the Congress, I practiced law for 14 years in the bay area. My firm organized about 25 generally high technology companies a year. Since I left the practice in 1967 and came to the Congress, that law firm has probably organized upward of 50 small high technology companies a year.

If there is any industry in this country that does not need preference on competitive bidding or assignments of government research, I would think it is the high technology industry.

Want me to keep going?

Mr. **Mitchell**. Yes; I would suggest that you just speak up as much as you can, and I would suggest that the members turn off their mikes while the other mikes are being used.

That might be a drain on the system. I do not know. In fact, with all of this expertise in the room, will somebody come up and fix this system? [Laughter.]

Mr. **Hess**. You need American Electronics Association.

Mr. **McCloskey**. Let me just refer to the committee report where you quoted Ed Zschau, who was chairman of the American Electronics Association when he testified before this committee in 1978 as to the problems high technology companies were undergoing.

Since that time we have enacted the Steiger amendment, reduced the capital gains ceiling from 48 to 28 percent precisely because the Congress was convinced that we ought to do something under the tax law to attract capital into this particular area.

Then last July we passed the restricted stock option, and we passed the R. & D. tax credit, again, first to attract people into small high technology companies with the attractiveness of the restricted stock option, and secondly, to set aside additional R. & D. moneys that these companies themselves could deduct.

Since that time, the testimony after you held your initial hearings has shown that the capital available for small high technology companies went from $39 million in 1977 up to $1.3 billion this year.

The one way to get rich still in America is to have the good fortune to have the $5 or $10 thousand available to invest in a small high technology company, such as Hewlett-Packard or Xerox. You can name 100 companies in my own district, or across the country, where people have become millionaires by investing in such companies as Apple, or Atari, where somebody had an idea that was exciting.

And there is no dirth of private capital to support an exciting idea. If you look at page 14 of your own committee report, if I can quote from that report, as a record of the NSF SBIR program has demonstrated, the small business innovation research program included in the legislation would supply a stimulus for the innovation process by providing for feasibility testing of new ideas with exciting commercial possibilities.

I really would challenge this panel for some testimony that any idea with exciting commercial possibilities is not going to attract private capital. I really think that the small businesses and AEA, which have opposed this bill, are right when they say small business thrives on a free enterprise competitive system. Why should a small business that is among the most successful in the country have to have a preference in the competition for awards?

It is an industry that does not need this help. Any idea that is exciting enough to have commercial possibilities is going to attract private capital. And it seems to me to give a preference to small business is both unwise and unnecessary.

I would be pleased to try to answer any questions, Mr. Chairman, on the thoughts that I have had. I would like to say I guess in conclusion to John LaFalce that I think the AEA has been honest in its presentation of facts. There may be disagreements as to what the facts are, but there has been no attempt to manipulate.

When Ed Zschau testified before the committees here, he gave the testimony that 5.5 percent of the research scientists were employed by small business, yet small business had received 6.8 percent of the research contracts in the preceding year.

If we are wrong on those facts, somebody can demonstrate them. But there has been no attempt to mislead anybody on the committee. Of the AEA's 1,900 companies, at least 1,400 are qualified small businesses. They are the beneficiaries of this bill.

I can tell you the AEA is headquartered in my district, and the large companies that were referred to as allegedly dominating the AEA do not. The kind of company mentioned, such as Hewlett-Packard and Lockheed, played no part in this decision to come forward on behalf of the smaller companies and oppose this bill.

What happened was that the smaller companies who had come before the Congress time after time saying, "Let us have a free enterprise system and let us have free competition," felt that it would be hypocritical to come in and ask for a preference after all of the years of testimony they have given before the Congress seeking fair competition and competitive bidding.

Mr. MITCHELL. Congressman McCloskey, I am very familiar with your opposition to this legislation. I don't have any questions.

I would call to your attention a statement made by one of the witnesses here, I think it was Mr. Hess, who said that the denial of access is a loss to the country, to the Government, and that small businesses don't gain that much by this proposal.

The secret is to bring their genius in so we can make our Government stronger, and certainly do business more effectively and efficiently. I have no questions.

Congressman LaFalce.

Mr. LAFALCE. I have no questions, Mr. Chairman.

I just want to say it is with regret that I find Mr. McCloskey opposed to this bill because of the great esteem I have for him. I think there are few individuals in the entire House of Representatives for whom I have greater respect. I cannot think of a more formidable foe, but——

Mr. McCloskey. Can I use that in my Senate campaign in California?

Mr. LaFalce. Reapportionment almost brought me to California. Why not. Go ahead. Thank you.

Mr. Mitchell. Mr. Smith.

Mr. Christopher Smith. Thank you, Mr. Chairman. I just have a couple of questions.

First, you talked about small business and the apparent non-need for this kind of set-aside. Dr. Hess, in his testimony just a minute ago pointed out, and I think it is a good argument, that lack of national name recognition often precludes a small business from getting a certain contract.

How would you respond to that. We in New Jersey have a very high number of high technology firms, and they don't have the name. It has been my feeling and understanding that they don't often get the contract.

Mr. McCloskey. I have not seen the denial-of-access problem in California. If you took the centers of the high technology industry, one would be northern New Jersey; two, Route 128 around Boston; three, in Texas; and probably the fourth in California.

We have not seen a denial of access. I would have no objection to the Congressman dating each agency to seek out requests for proposals and to make the RFP's known to every small business in America.

My problem is that when you mandate 3 percent and specifically say in the legislation that that 3 percent is on top of any competition for a free market bidding, you make a jungle of bureaucratic nightmare to comply with this law.

I have no problem at all with mandating access. I think that is entirely appropriate.

Mr. Christopher Smith. It is my understanding that access is not the problem at all. They may know about it and know that they may bid on the particular contract, but when it comes down to bidding, many of the small businesses that I have been in contact with say it is weird. There is no way we are going to get this.

Perhaps I would yield to Dr. Hess if he would like to further comment on that.

Mr. Hess. No, I think you have made the point well.

Mr. McCloskey. But can you cite a specific example where a small business has been unable to compete with a large business?

Mr. Mitchell. It was cited in your testimony, was it not?

Mr. Hess. Yes, I cited one example in our own case. Again I would emphasize that for my company, for members of the American Council of Independent Laboratories, the loss presently is to the Government, not to our group, because we are doing all right in the private sector, and we refuse to get involved in these races that add up to no contracts anyway.

Mr. Christopher Smith. I also think there is perhaps a chilling effect on many small businesses that would normally apply for the contracts. I have talked to many small business people in my district and adjacent to it, again I mention the Princeton area right next door, in several of the counties where there is a very high preponderance of high technology small businesses. They tell me that they look at the solicitations to bid and say "What is the use?" It is weird. The larger corporations, whether it be Xerox or some of the others will be getting it and we wouldn't be.

So there is a chilling effect, which again freezes out many of the would be small business people who would get involved in this.

Then, as mentioned by Dr. Hess, and I have heard it too, there are times when they just don't get it even though they think they are low in terms of the bid.

Mr. McCLOSKEY. But that then violates the law, doesn't it?

If the lowest and most qualified bidder——

Mr. CHRISTOPHER SMITH. The key word is "qualified."

I used to do bids in my small business. We were often barred from receiving the bid because the discretion was left up to the agency. At least that is the way it was on the State level.

We could be low man but because we didn't have the record and, as one of the witnesses pointed out, how do you get a record? It is like don't apply without job experience; how do you get the job experience?

I think, and point this out, we are losing a great number of small businesses that could be very much a part of the great breakthroughs and innovations in getting product to market by not going along with this very modest, very modest 3 percent setaside.

I would gladly yield to Dr. Hess.

Mr. HESS. Could I make a distinction between two types of arrangements with small business that we might be talking about?

Reference has been made to the small businessman with a hot new idea and he doesn't have the funding to do the preliminary research. I am coming from a different point of view, in which we are saying here are small businesses with high technology capabilities to provide an answer to the needs of Government and to the private sector.

Now probably the reason you don't know my company is that we have never invented a Xerox or something that went great big.

On the other hand, innovation I think oftentimes comes in multiple small pieces. It is those kinds of things that really get things moving in a workplace and the Government has all kinds of needs that small business can supply much more effectively than anyone else. I am saying we are being denied that.

Mr. MITCHELL. Thank you very much.

Mr. Smith.

Mr. NEAL SMITH. I want to reiterate the point, we are not really talking about a preference for small business. We are talking about trying to correct a preference for big business and make Federal opportunities equal.

The only way you can do that is to have a little bit of preference left for small business so both big and small can be involved in the game.

Mr. McCLOSKEY. Could I ask the gentleman from Iowa, what is wrong with requiring competitive bidding?

Mr. NEAL SMITH. That is the requirement now, but you don't get competitive bidding when you rig the specs, when you don't give equal time to the small businessman that comes in and tries to present his case when you in fact ignore him just because you don't recognize his name.

Mr. McCLOSKEY. Can't you write a law to that effect? If I said to the gentleman that if the law said that there shall be no discrimination against equally qualified bidders because one is small rather than large, wouldn't that solve the problem?

Mr. NEAL SMITH. You have still got the problem that 90 percent of it is administration and the person administering it sitting here at the desk. If it is a government desk, it doesn't involve possibility of his making $1 million and we have found this to be especially true even at NIH, of all places.

They just simply didn't want to bother with this guy that they haven't heard of that doesn't have the reputation, the name; they haven't got all the background on him and they have to go through all this extra work.

I just think we don't give equal opportunity for small business unless we do something like this to give some of them a chance to get started.

Mr. CHRISTOPHER SMITH. Would the gentleman yield?

Mr. NEAL SMITH. Yes.

Mr. CHRISTOPHER SMITH. Just further on that, talking about competitive bidding, it is my understanding over 70 percent of the Federal expenditures for R. & D. contracts are made through noncompetitive award instruments, so we are not talking about competitive bidding.

Mr. NEAL SMITH. You are very correct.

Mr. McKevitt, is this going to be on your index, the vote on this bill?

I didn't want to do anything to hurt it.

Mr. McKEVITT. Yes.

Mr. MITCHELL. With all due——

Mr. LAFALCE. If that is the case, Mr. Chairman, I may have to withdraw my sponsorship.

Mr. MITCHELL. Gentlemen, this colloquy is quite entertaining, but I think we had better get on with the business at hand.

Mr. Weber.

Mr. WEBER. Would you, Mr. Chairman, mind coming back to me in a little while?

Mr. MITCHELL. All right.

Mr. Bedell.

Berk, just before you speak, I am advised that the electrician is suggesting that they cannot fix this system while we are in progress. So, as soon as we finish our discussion with you, Mr. McCloskey, we will take a 10-minute break. I hope that they might be able to fix the system in that time and we will then return to the other witnesses.

Meanwhile, if there are any volunteers to do this, and I am sure it could be done with dispatch while we are in progress, please come forward. We would be delighted to have you.

Mr. Bedell.

Mr. BEDELL. Thank you, Mr. Chairman. I would like to echo the remarks of Mr. LaFalce.

Pete, you and I have been on the same side on almost every issue that has come along. I am greatly disappointed we don't happen to agree on this one. I respect your judgment very, very much, and I particularly appreciate the way you have listened to the arguments here because I have great hopes that very likely you will change your mind as you understand the problem better.

Mr. MCCLOSKEY. Well, may I respond just briefly and ask that there be included in the record at this point a letter from the American Farm Bureau Federation—which I think covers both Iowa and other places of that kind—stating that the Farm Bureau Federation has now come out against this bill because they feel it will divert agricultural research moneys unwisely.

Maybe that will help persuade you to change your mind.

Mr. BEDELL. Well, we talked a little bit, Mr. McCloskey——

Mr. MITCHELL. Did you really want it in the record at this point? Without objection.

[The letter referred to above follows:]

AMERICAN FARM BUREAU FEDERATION,
Washington, D.C., May 3, 1982.

Hon. Paul McCloskey,
U.S. House of Representatives,
Washington, D.C.

DEAR CONGRESSMAN MCCLOSKEY: We understand that the House of Representatives may begin consideration of H.R. 4326, the Small Business Innovation Act, in early May. As you know, the bill requires federal agencies, including the U.S. Department of Agriculture, to allocate three percent of their research funds to small businesses.

Farm Bureau opposes H.R. 4326 because the allocation of three percent of USDA formula funds to small business firms to conduct research is not the most appropriate way to promote the well-being of small research firms or to stimulate agricultural productivity.

The allocation requirement would negate the small increases in formula funding recently received by the USDA. In addition, the number of small firms specializing in agricultural research is limited. A diversion of USDA research funds to them could mean exceptionally large contract awards without necessarily increasing the quantity or quality of agricultural research.

Farm Bureau asks you to consider the effects of the bill and to oppose it because it provides no real benefit to either the small business or the agricultural communities.

Sincerely,

JOHN C. DATT,
Secretary and Director, Washington Office.

Mr. BEDELL. The Farm Bureau tends to be pretty good on agricultural issues, Mr. McCloskey. You made quite an issue of the lack of capital. I would state I don't think that is the real issue.

There is capital available to big business. The problem is that a great many businesses are not in the position to put that money forward for that type of long-range research. If big business is not willing to do it, then I submit that if you are saying that there is capital available to small business, that is not an argument that is relevant to this particular issue.

There may be an argument as to whether small business needs or does not need capital, but I state it does not have to do with this particular issue which is pure and simple that some of us believe that we should eliminate preference within the Federal Government.

You are surely aware that in NIH they have a peer review system. There are 2,000 people involved in that peer review system, of which 6 come from business.

Six out of 2,000. It seems to me that is pretty clear as to where their preference is going to be. We have tried to do what you are talking about time after time after time in legislation, pleading with these agencies to try to open things up so that there is some objectivity so that there is equal opportunity to compete, but frankly we have been unsuccessful in that effort in that the agencies simply have refused to do it.

They say they are going to do it, and everything is great, but then it comes back. It simply is not done. I would urge you to look at this objectively as to just exactly what is happening there within the agencies.

Mr. **McCloskey**. Could I ask a question of my colleague? Do you not see some danger that, if you create a preference for a given kind of small business to get these awards, that there will not spring into existence the kind of company that comes into existence solely to compete for a Government award that is set aside for that kind of business?

I grant you that if you could prove denial of access to small businesses, you have a point; but if you mandate that in addition to the competitive field of competitive bids or sole source procurements, you have got to add on 3 percent that goes to small business, you are likely to see a lot of people grow fat on the Government dole by forming companies to take advantage of a Government setaside.

It seems to me that is a real risk. If you have got an idea that is merchantable, you can get the capital for it without going to the Government.

Mr. **Bedell**. But you understand the relatively small amount of money we are talking about here in these three funding steps contained in this bill, which is $50,000 for the first step, I don't think you can get rich. The first phase has to be successful in order to move to the second step. So we are not talking about the Government giving a lot of money to somebody that thinks they can do something with an idea that they have.

I yield to the gentleman. Mr. LaFalce.

Mr. **LaFalce**. Thank you.

Pete, I said when I came here that we had so many witnesses that I was neither going to ask questions nor engage in any debate at this time; that I would save my ammunition for the floor, but let me deviate from that just for a second to point out what I think perhaps is the most important issue and one that you have not touched upon thus far.

I think perhaps we could join issue on this. Or perhaps both of us could reflect on it. What I consider to be most important about this bill is the word "innovation" and the fact that we would be seeking to pursue innovation.

Small business benefits incidentally from this. The reason that small business is going to be eligible for these moneys is because we have data which indicates that small business historically has been far more innovative than any other sector of the economy.

Therefore, if Federal moneys are going to be used for the purpose of innovation, it would be good if we could put out a portion of that money for which small business could compete and obtain separate and apart from the other moneys that they must compete for with all other classes of people.

Now, I still haven't crystallized the point that I want to make and that is this: This 3 percent that would be set aside for which small business could then compete would not be moneys for which there are contracts that have been determined by the Federal Government. We will not have somebody from NIH saying here is $100,000 that we have. We want research to be done on project *x*. We wouldn't have DOD saying that either.

What we will be having is a program where there will be a pot of money and we will say to small business, come up with the most innovative ideas you possibly can come up with that will have some potential payoff. Then you might get 1,000 small businesses. They don't have to look at any request for bids, they don't have to look at these specifications, and so forth. And out of these 1,000 applications 100 might prove most promising, most innovative, and come up with some ideas for which the Federal Government never had any idea that maybe research would be done in that area.

The innovative quality of this, it seems to me, will be tremendous, and the payoff, incalculable. I don't think that can be done under the existing scheme of things.

Mr. **McCloskey**. I can't quarrel, if the gentleman will yield, with a thing that you have said, but I would quarrel that the bill you have drawn will accomplish that result.

Mr. **LaFalce**. Let's perfect it then.

Mr. **McCloskey**. Well, I would hope so. But the bill you have drawn says to the Department of Agriculture, for example, if you are spending $20 million on research this year, 3 percent of it has got to go to qualified small business companies.

Now, the Department of Agriculture is going to want to spend its $20 million for the best research it can get to meet the Government needs for research in a given field. If the Department of Agriculture wants research, say, on what the relationship is of acid rain to the productivity of the soils of Iowa, you are saying we will get a better innovation answer on that research from a small business than we will from a large.

But the definition of what research must be is going to be set by the Government. Now, if the Government says we want research into this field, how are you getting more innovation rather than less out of a little company rather than a big one when the Government has defined what it wants?

It seems to me that the Government lays out its requirements and we in Congress override them to make sure we are getting the best results for the dollar.

How do you then skip to the point where the little company is going to give you a more innovative answer to the Government's needs than a big company? That is my problem.

Mr. **Bedell**. Mr. Chairman?

Mr. **Mitchell**. Yes.

Mr. **Bedell**. If I could reclaim my time, I have to go to another meeting. They are trying to knock out one of my amendments in another committee.

I want Mr. McCloskey to know that I haven't given up and still have great hopes we will convert him over to seeing the great benefits from this legislation.

Mr. **LaFalce**. And I want Mr. McCloskey to know that any kind statement I made he can certainly use in his primary election campaign.

Mr. **Mitchell**. I would like all to know that we need to move with dispatch. I think it is a little unfair to keep as many witnesses waiting as we have.

With that I will recognize Mr. Weber.

Mr. **Weber**. No, I will pass.

Mr. **Mitchell**. Mr. Roemer. Thank you, Mr. Chairman.

Pete, let me make sure I understand your fear or concern about this bill.

In looking at your statement and listening to your talk, I sense your concern is that the bill wouldn't do what its amendments state it will do.

Does it go further than that? Are you concerned about something else?

Mr. **McCloskey**. Two things I am concerned about.

Reading the bill, you know it will cost $38 million a year. In my testimony I have referred to the one agency, the National Science Foundation, which has tried this kind of program. Their general counsel has written a letter to OMB saying he feels it would be unwise to try to extend this small program across the Government without at least a greater understanding of the success or failure of the small program.

The biggest problem I think is that you are saying to the Government that it must dedicate 3 percent of its money to small business. It seems to me whenever you put a preference in anything for any purpose you add to the cost of the bureaucracy and recordkeeping.

I have led an effort to abolish the Renegotiation Board and the Vinson/Trammell Act last year because of the paperwork problems imposed on small business.

Small business will tell you quite honestly the things that make them uncompetitive is that they can't maintain the staff of lawyers and accountants to deal with Government paperwork like the big company can.

This bill imposes additional paperwork and recordkeeping; in this case to the cost of $38 million a year. My former colleague, Mr. McKevitt, from Colorado, I have always understood small business to oppose Government paperwork and regulations in order to avoid that burden on productivity?

So we have a bona fide dispute here, whether setting aside 3 percent helps or hurts small business.

Mr. **Roemer**. If that is your concern, let me state for your information our concern, at least mine is directly opposite to your feeling.

No. 1, we live in a country that is losing ground in terms of innovation and technology. Some would dispute how fast we are losing ground, even to the Japanese or other forces, but we are not as secure as once we were or as we desire to be.

Add to that the fact that statistics clearly show that innovation, net job gain often comes down on the sides of those companies that have 50 employees or fewer, that is, small business.

Add to that a third fact of life. I guess George Orwell wrote it best in "Animal Farm" when he said all animals are equal but some animals are more equal than others.

When it comes to Government contracts, small business, either through lack of experience, lack of the large staffs, as you point out, of lawyers and/or accountants, and a lack of contact within the agencies, suffer a disadvantage.

Couple those three things together, Pete, and that is why this legislation is where it is now. We are generally concerned about it. If there is a better way to do it, by golly, let's hear it.

We don't see it right now.

Mr. McCloskey. Well, if I could respond just briefly and from the experience in my own district and across the country, every industry that is coming to the Government for help today is an independent industry that has benefited by Government preference in the past.

If you take shipyards or steel or automobiles or any of the great industries now coming to us for help, you almost reach the conclusion that the worst thing that can happen to a competing business is to do business with the Government or have a Government preference.

Lockheed is the biggest employer in my district. I voted against the Lockheed loan guarantee a few years ago. I thought I would get defeated. They employed 12,000 people. It turned out a majority of the Lockheed employees thought they were somewhat inefficient because of that Government assistance that they were getting. When you get Government guarantees and Government money into a competitive system, you get less competitive rather than more.

I suppose it is an inherent desire to see a free competitive market system work rather than a preference system.

Mr. Roemer. I sympathize with that and I will close by saying that I understand your concern.

But, let me point out to you, the preference is small, the benefits great. The preference for competition is alive, Pete. It exists in those agencies right now and the proof is the record of who gets the contracts.

Mr. Mitchell. Thank you.

Mr. McCloskey. I have taken too much of your time, Mr. Chairman. Thank you.

Mr. Mitchell. Congressman, before you leave, we are going to come back to this panel after a 15-minute break. You might want to stay and hear the next panel following this. It is a panel made up of National Science Foundation award winners, all of whom support this legislation.

Thank you for being here. You have not changed my opinion at all, but it is always good to see you.

Suppose we take a 15-minute break and then the panel will resume right here.

[Recess.]

Mr. **Mitchell.** Ladies and gentlemen, unfortunately the system has not yet been fixed, but I don't want to delay too long, so if we could have our panel back, please.

If the members of the panel will come back up, please.

I will ask for the cooperation of the audience in trying to hold down your conversations. They are trying to work on the system. However, I just think that we can project loudly enough to go ahead with the hearing.

So many people are under time constraints, and I think more delays would be unfair. So if we could have as much quietness in the hearing room as possible, please, because we are working under great difficulty.

I will ask all witnesses who come up to project as much as possible.

I have only one question to this panel, and that is, someone approached me about compromising on the bill and saying that as an area of compromise we ought to eliminate the basic research because small business doesn't do basic research, and they are not very much concerned about it.

I think I know what your response will be, but could I hear from all of you gentlemen in response?

Mr. **Hess.** By all means, don't eliminate it. As small businessmen we feel perfectly comfortable competing with universities and nonprofits for basic research. But for heaven's sakes, I think we can and have performed on some truly fundamental work on which we then develop innovation.

Mr. **Mitchell.** Your testimony was certainly evident to that effect.

Mr. **Hess.** That would really create a lot of problems in defining where that grey area is.

It would just leave agencies another loophole.

Mr. **Mitchell.** Mr. Schellin?

Mr. **Schellin.** Yes. In response to your question, Mr. Chairman, may I also make a few comments relative to Congressman McCloskey's comments with regard to his clients, former clients, when he was in private practice coming to his law firm at the rate of 25 per year to be organized as small high technology companies, and now I understand it is 50 a year.

I would like to point out that when he saw those clients, they were at a stage where the innovations were packaged. This is what I was referring to early on in my testimony.

A small business is good on packaging the innovation, and it is the package that attracts private investors. Ideas by themselves do not attract private capital.

Ideas by themselves must be developed through basic research and small businesses are adept at that also. They just haven't been given the kind of opportunity under the present system of preferences to either large businesses or to nonprofit institutions. This particular legislation is supposed to ameliorate that shortfall.

So what we need first are creation of new ideas. small business can play a role in that. As I said before, naked ideas by themselves are never going to attract private capital.

Mr. **Mitchell.** Mr. Lee?

Mr. LEE. I don't believe that if you look at the technology transfer process you can piecemeal it.

If the idea is simply to generate ideas and toss them into the public arena, I suppose it doesn't matter, but we are talking about taking ideas and moving them into the public marketplace where the public can benefit.

You have to look at the idea from the perception all the way down to the market. I don't think it can be looked at piecemeal.

Mr. MITCHELL. Therefore keep basic research in?

Mr. LEE. Yes, but make sure it is seen as one of the early stages of the whole process.

Mr. MITCHELL. Are there questions?

Mr. Smith?

Mr. CHRISTOPHER SMITH. No real questions. Perhaps maybe one. Much has been referred to—Mr. McKevitt talked about small firms produced 24 times as many innovations as large firms. I think this committee, and I believe all of you would agree that small business does get out there and do much of the R. & D. work. Has there been any study as to the time equation?

That is to say, when an idea begins to germinate and then finally goes to the point of being packaged and actually turns into a product, are there any studies that you know of where the time element was studied vis-a-vis the larger corporations?

It might be hard to categorize, but what I am thinking of, it would make a very persuasive argument to show that the time is cut back when a small business gets involved in one of these things because they work maybe the extra hours. They are lean and mean because if they don't produce the small firm may go under.

Mr. HESS. I am not aware of such formal studies. I would only say that I only survive in business because I am efficient, both on turning things around rapidly, and at low cost, because most of my competitors really enjoy the tax-free status, which I don't.

Mr. SCHELLIN. I would respond to that.

The only study that comes somewhat close to what you are interested in that I am familiar with—and Milt Stewart can undoubtedly provide more info on it—is a study that was undertaken through a contract by the Office of Advocacy at the SBA. Judith Obermeyer undertook that study. I can get you a copy.

Mr. CHRISTOPHER SMITH. Will you, please?

Mr. SCHELLIN. I will be happy to.

Mr. MITCHELL. Mr. Lee?

Mr. LEE. I don't know of any study but I think what you are saying is whether there is a way in which you can find a contrast.

Mr. CHRISTOPHER SMITH. That is precisely what I am looking for.

Mr. LEE. I think it shouldn't be very difficult to inquire among large businesses as to what they consider to be payback periods and return on investment hurdle rates, to use their words.

I think that although there may not be a study, big business has certain ground rules by which they eliminate projects that take too long in incubation.

Typically, your high technology projects take a lot of incubation time, which means they do not survive in big business.

Mr. CHRISTOPHER SMITH. Thank you.

One comment.

Mr. **Mitchell**. Sure.

Mr. **Christopher Smith**. I appreciate all of your testimony. I think you were very, very persuasive. Mr. Lee especially, your pointing out that your colleagues at Cornell agree small business has a great deal to offer.

You know, this adversarial relationship that has been engendered through the legislation I think will be very shortlived.

Also, to Dr. Hess, you pointed out this will cost the taxpayer absolutely nothing. In these times of budget cutting, I think that is important.

Mr. **Hess**. It will save a lot.

Mr. **Christopher Smith**. It will actually save money through wise use of scarce funds.

Mr. **Mitchell**. Gentlemen, thank you very much. It got to be a very interesting session.

Certainly you contributed significantly to the interest in this area. Thank you very much.

Our next panel is comprised of Mr. Stan Mason, president of Simco, Inc., Weston, Conn., and Dr. Orrie Friedman, president of Collaborative Research, Inc.

If you go back, all of the panelists here, Mr. Mason, Mr. Friedman, Ms. Andrulis, if you go back over the record of the hearings that I have conducted, each time you will see me making an apology.

It is awfully tough for businessmen and women to take time from their business to come here and testify. There are a thousand problems waiting for you when you get back. I am just very appreciative and grateful you would take the time to be with us.

I think we have copies of your statements. If you will proceed, let's lead off with Mr. Mason.

PANEL CONSISTING OF STANLEY I. MASON, JR.; AND DR. ORRIE M. FRIEDMAN

TESTIMONY OF STANLEY I. MASON, JR., PRESIDENT, SIMCO, INC., WESTON, CONN.

Mr. **Mason**. Thank you, Mr. Chairman.

I am president and founder of three small corporations: Simco of Connecticut in Weston, Conn.; the Masonware Corp. of Newport Beach, Calif., and Simco of Texas in Houston.

I am also the chairman of the Emergency Committee to Enact the Small Business Innovation Research Act of 1981.

I am pleased to be here today to tell you why I believe you should support the Small Business Development Act.

In a capsule, it is my experience that Federal funding of research in small high technology companies does not compete with basic research in universities or in large corporations.

In fact, such funding will reinforce the use of basic research, and help create jobs.

I believe that we can agree that 3 percent is truly modest, especially when we are talking about the big dollars going to basic research in universities and large businesses.

I can see the point of view of the universities. There really is not a lot of money out there.

You can agree that the universities, and the big corporate labs are doing important work, but Federal funding of research in small companies doesn't really compete with basic research.

We are really not competing if you look at the larger picture.

We must look into what 1 to 3 percent can contribute in social and economic gains for the country. It multiplies. It is not simple addition.

There is no need for me to reiterate the statistics of previous testimony other than to remind ourselves that the majority of all patents come from individuals and small organizations. They don't come from universities and big business.

Likewise, 80 percent of all new jobs are generated within small business and not by universities and large businesses.

There are reasons: The first reason is risk; the risk-taking attitude and creative ability and the entrepreneurial spirit of small firms.

Risk is truly the economic river for the small firm's personal and corporate income and growth, and subsequently the payment of taxes which in turn support the universities and basic research.

This economic driver, which I call risk simply does not exist within the incentive psyche of university staffs and researchers, nor does it exist within the mind of the large corporate researcher.

Please don't misunderstand me. There are certainly brilliant and effective people in university R. & D. staffs, and in large companies.

We in the small, high technology community know that the coupling of the basic research generated within the university, to the large corporations' strengths, is one of our best and most needed skills. This is what really produces economic and social benefits, but I am getting right now to the basic point.

That is, that everybody in this room knows that the people in the small company and the people in the large companies are different kinds of people. There is a different outlook, a completely different feeling.

I have seen this difference in my small companies. Simco of Connecticut is a think-tank group which has a laboratory. We invent new products and processes. That is what we do for a living. Half of our time we work on wholly owned proprietary products. The other half of the time we work on client programs for about 18 Fortune 500 companies.

The Masonware Corp. markets a line of microwave cookware which we developed and patented 6 years ago. These were the pioneer products in the market which is estimated to be $430 million a year. Giant companies such as Corning and Anchor Hocking followed the lead of Masonware into the market only after we pioneered the product.

Masonware is sold internationally and in the United States it is sold by Sears, Penney's, and others. We proved that the risk was less than I guess these large companies had imagined.

Simco of Texas is our horticultural and energy group. What we are doing is developing the Chinese tallow tree as a source of petroleum substitutes and I have some of the seeds from that tree right here.

Briefly, when the seeds of this Chinese tallow tree are squeezed, the oil can be put in a diesel Mercedes or a Rabbit and the engine will run just as efficiently as though it was filled up at the diesel truck stop down on Route 1.

In a moment I will light one of these and show you the energy in it.

I am really delighted to speak to the committee today about research and development in general, and about the potential of small business innovation in relation to universities and large companies.

I speak to you as a person who has lived his career in both small and large companies. These large companies had at least 30,000 to 50,000 employees. The small, as few as three people.

I started my work at the United States Steel Corp. as a draftsman. I developed my first invention there at age 21. I was a pilot in World War II. I was a copywriter at the Armstrong Cork Co. I was a tool engineer at the Martin Aircraft Co. I set up a small plastic adhesives company.

I developed new products at Hunt-Wesson Foods and most recently, before I set up my own firm some 10 years ago, I was vice president for product development and technical services at the American Can Co., which is much more than a can company. It makes all kinds of products: paper, metals, plastics, and so forth.

I was responsible for nine laboratories and an operation of about 500 scientists and technologists.

In 1973, I organized Simco of Connecticut. Since that time, we have been doing all kinds of work in high and low technology for companies such as Johnson & Johnson, Johnson's Wax, Frito-Lay, American Can, Lipton Tea, Tupperware, Nestle, and a large group of others.

We actually develop new products and solve special technical problems for these companies. We support the internal scientific and marketing organizations. We do not compete with them.

However, we are not ordinary consultants. We are not just a recommending group. We actually create and develop new products. Client companies hire us not only for our innovative ideas, but also because we can often complete the work faster and cheaper than they could do the job internally.

We bring a view of the outside world uncontaminated by internal politics or scientific prejudices.

Why would large companies with all their resources come to little guys like us?

For many reasons.

First of all, as a small broad-based group, we can pay attention to the things that count.

Another thing, we can exert more focused technical direction and financial control than they can.

We put talent with greater technical specialization on the job than they can. We can assure more continuous management and followthrough on a project than they can.

We can do these things for two reasons: First of all, we operate on a principle which a lot of people call networking; we call it focused problem solving. What we do is put our own scientific talents, with those of a broad spectrum of associates within universities across the country with whom we have been working over the years.

You might ask why our large company clients don't just hire the university people directly? Or why don't the universities pursue their product development relationships themselves?

There is a good reason. And it has to do with the fact that the entrepreneurial spirit is just not often found in either the university or within large organizations.

There is simply a difference in the kind of people in large companies, university labs, and small companies.

In a large company, if a young technical man is good, and he is just out of college, he is assigned to work on the bench. His assignments stay within his technical skills for 1 or 2 years. Then he is promoted. He directs the work of others.

If he is really good, up the ladder of management he goes. Now he is not dealing with the technical work any more at all. He is not inventing, or working with innovations.

What he is doing is signing vacation vouchers, or decorating the office, or visiting customers.

There are exceptions, of course, organizations such as Bell Labs and others. But generally in large organizations of all types, the technical work is really left to the lowest level of people, the newcomer, and the inexperienced group.

Certainly I can't say that scientists and technologists who work for large companies aren't intelligent and creative. They are. But I can say that scientists and technologists who work for small companies are not signing vacation vouchers and writing brochures. They are working on science and technology, day in and day out.

Now, let's look at small companies. They are made up of some of the best scientists and technicians. Their people apply their technical expertise as it grows, to the technical problems and opportunities of invention and innovation, even when they are at the top of the organization.

I speak from experience. I am 60 years old. I have received more patents in the last 10 years since I have been in my own small business, than I wrote for the 30 years previously.

While I have been the same man all through my career, I just decided to do it for myself. I believe that the incentives for personal satisfaction and for financial reward just cannot be compared.

Large companies aren't sinister, and they certainly are not anticreative. But I have found myself that innovative people are literally driven out of large companies. They are pushed out by subtle and sometimes overt pressures.

I know to make it in a large company you really must conform. If you do not, you are not promoted. You might even get fired.

The corporate mold varies from company to company, but it certainly is true that truly creative people find it difficult to fit into any mold, so they escape.

To make it in a large company, for instance, it might help to be tall, handsome, and articulate. It also helps to be conservative. You must not take chances with the company's money. You have to make it in 2 years. If it takes 3 years, you don't do it.

Generally speaking, the small company is not interested in how you look. It is what you can do. The small company is interested in your ability to do a creative job, and the small company will often encourage you to share the results of your innovative nature in royalties and in shared ownership in order for you to get a piece of it.

Let me make it clear: I am not attacking large companies or universities, far from it. They are the heart of the country's strength. They have produced the wealth and the power that we are in America, and they are also my customers.

The point I want to get across is that right now and throughout the last 100 years the greatest single source of ideas and jobs has come from the small companies.

This is the crux of my testimony: If small companies produce the most innovative ideas and products and jobs for the Nation, why not help them? Give them the incentive of the 3 percent. This legislation is truly important to the future health of the country, both long and short term.

The equation is very simple. For example, if a dollar put toward supporting R. & D. in a large company or university produces x return for the country, that same dollar will produce x times 50 or 100 if you support R. & D. in small companies.

It is a good proposition. It has very low risk. It can be evaluated by dollars, or by public good in social and economic values.

What I am getting at is just a matter of priority. It is not that we want to give less emphasis to university or large corporate R. & D. It is simply that we want to recognize the potential of the small company R. & D. We want to be sure the money is used in the most productive way.

Now I want to tell you about this tallow project because it is an example of the support small high technology companies get through the NSF small business operation. This whole program that you are looking at has been modeled after the NSF program.

The work that Simco has been accomplishing in the Chinese tallow tree project is of considerable complexity. It involves a network that is national in scope, with simultaneous effort taking place in universities, cooperative government labs, the Texas State government agencies, and the development departments of more than 10 corporations.

Under the direction of Dr. W. H. Scheld, Simco's director of research and principal scientist in Houston, Simco has been supporting the study of the oil aspects of the Chinese tallow for more than 5 years.

The tallow tree is an interesting and potentially important substitute for petroleum because it is capable of producing 10,000 pounds of seed per acre from poor, marginal, wet, salty soil where hardly anything else will grow. It produces much, much more vegetable oil per acre on this poor soil than conventional oil seed plants, soybean, and so forth, does on good soil.

Tallow oil needs no refining as petroleum does. Farmers can make at least three to four times as much on Chinese tallow from marginal soil than they can from corn or cotton on good land. It is not a new crop. It has been grown in China for centuries and has been an export commodity for a long time. It has no important insect or other enemies.

In spite of all these advantages and all of our work initially and all the money I have personally put into it, we had a very difficult time getting any corporate interest in this crop mainly because corporate investment usually must be returned by the project in 2 years.

Then the people at the National Science Foundation heard about us. We actually did not seek them. They heard about the possibilities of the Chinese tallow and our work. They are really the innovative people.

We were able to create a technical proposal, and with minimum redtape, and I really emphasize that, and it was not a complicated thing, it was funded by NSF at the $25,000 level. This is truly modest, but it represented recognition to us and to potential investors that we might have something.

With this NSF funding, we organized a detailed, carefully thought out program of development: genetics, selection, cloning, development of harvesters and marketing considerations, including the use of the oil in a wide range of applications far beyond the use of the oil as an alternative fuel for diesel engines.

It can be used for food. It can be used for drugs, for synthetic lubricants and for plastics, as well as for diesel oil.

We invested, that is, Simco invested more than the grant sum in background work and in preparation of the proposal so it would be complete and would represent good science and be a real blueprint of a viable program.

The point is, without the NSF incentive, the fine reputation of NSF, the careful hands-off yet experienced science policy guidance from the small business people at NSF, Simco would have never organized a program with such drive and care and precision on its own. Perhaps the Nation would never have had the opportunity for such a rich source of renewable energy as this tallow tree offers.

We really do need to press forward and allocate the funding to small business research. It will return this sum, with much interest, year after year.

Now I am going to burn one of these seeds for you and sometimes they pop if they have a little moisture in them, but on the outside is white tallow which is an edible fat which can be made into margarine or soap or candles or can be made into a substitute for coconut butter. Now, the inside has a liquid oil in it there, you see that? You see it burn out there? There is a jet of oil coming—see that?

Mr. MITCHELL. Yes.

Mr. MASON. It is going to burn me. But this is just one seed. Just imagine 10,000 pounds of these from 1 acre. Boy, it is getting hot. But you can crush these in conventional equipment already in existence. You can grow it on poor land along Texas, all the way from South Carolina down to Florida, all the way across Texas. There are about 50 million acres available. It can bring farmers new crops. The main thing that it is, it is a substitute for fossil fuels. It is a renewable resource.

We squeezed a large number of these, and put the oil in a German diesel engine test bed, and watched the computers as we switched from regular diesel to this tallow oil. There was not a change in r/min or any other power output! It was absolutely fantastic!

Thank you very much.

Mr. **Mitchell**. Thank you very much.

Mr. Friedman.

Mr. **Friedman**. Thank you.

TESTIMONY OF DR. ORRIE M. FRIEDMAN, CHAIRMAN AND CHIEF EXECUTIVE OFFICER, COLLABORATIVE RESEARCH, INC., LEXINGTON, MASS.

Mr. **Friedman**. Mr. Chairman, members of the committee, I thank you for the opportunity to testify before you in regard to this important matter, the Small Business Development Act.

I will tell you a little of my background.

I spent many years in academic work as an assistant professor at the Harvard Medical School, and later as a professor at Brandeis University.

I am the chairman, and chief executive officer of Collaborative Research, Inc. This is a high technology company in the biotechnology field. I think we are one of the leading companies involved, among other things, in applying recombinant DNA technology to a variety of commercially valuable products and processes.

Our company has recently, in the past 6 months, raised a total of $20 million through private placement with companies such as the Dow Chemical Co., and the Green Cross Corp. in Japan, and within the past 2½ months completed a highly successful public stock offering underwritten by Merrill Lynch.

We were particularly pleased by this because papers like the New York Times were making a career out of predicting that we would fall flat on our face in that the market could not absorb an issue of this type.

In fact the issue oversold within a period of 1 hour from the time it became effective.

I would like to take a few minutes, if I may, to give you a brief account of the history of this company since I believe it contains some lessons of particular relevance to the present concerns that we all share.

The circumstances surrounding its founding are of some interest as at the time, as I have indicated, I was pursuing a successful career as a full-tenured professor of chemistry at Brandeis University. In the course of this career, I have been responsible for the development, among other things, of the drug Cyclophosphamide, which is one of the most successful and widely used of the cancer drugs that have been as yet developed.

This is used worldwide in this country, abroad, Eastern Europe, Western Europe, the Far East, and so on.

Though I had no idea of entering into business at the time, I was approached by the National Cancer Institute asking me to apply for a large research contract to greatly expand the research activities in the cancer drug development field in which we had pioneered. I declined, stating that large-scale developmental activities of the type that were contemplated were inappropriate in a university setting and were best carried out under private auspices.

I won't go into details, but I set about raising the money to support this company, set up a contract proposal and had to disqualify myself from all the committees on the National Cancer Institute where I was very much involved.

I was on their panels and was a special consultant to the National Cancer Institute and so on, and I was successful in winning an award, award of the contract for which I had applied, and then launched into this venture which I have been pursuing ever since.

In so doing, however, I must say that I had extravagant ambitions in starting this business in that I intended one day to become a major factor in the biomedical enterprise.

It was on the basis of this contract and many other contracts that were awarded to us by a wide variety of Government agencies, including Defense, as well as the NIH and the Quartermaster Corps and so on.

As these were eventually the total source of our financial support in the first few years of the company's existence, it was the support of research by the Government agencies through which we gained the experience and the technical skills that enabled us to build the company.

Using these skills, we were able to accomplish two things: One, as we were doing sophisticated research, often at the cutting edge of science, we developed a number of specialty biochemicals that were needed for our own work, and we were able to manufacture and sell to many other investigators worldwide, thus enabling us to establish a commercial business, which incidentally has been very successful and has earned us a great deal of money over the years.

Two, increasingly we were able to attract support for research contracts from the private sector, mainly, phamaceutical, until we have come to the point now where Government contracts account for only a few percent of our total revenues. These arrangements with private companies were initially simple research agreements, but they have now evolved to the point where these arrangements involve licensing and joint venture provisions.

Now, to bring you up to date quickly, the breadth and depth of our skills in biotechnology have enabled us to establish great expertise in genetic engineering and this has opened up for us many very interesting commercial opportunities.

As I just mentioned, during the past 6 months on the basis of a private placement with Dow Chemical, and the Green Cross Corp., and the public stock offering, we have raised about $20 million in equity capital on market a evaluation of the company at $100 million, and we feel in fact that we were undervalued relative to other companies in the industry. This influx of money is enabling us now to fund the development and commercialization of our technology on our own rather than through other companies. The company is growing explosively, and the prospects look extremely good. We, in fact, project that within a period of 10 years this will be a major corporation. In fact, we project sales in excess of $300 million within that period of time.

Incidentally, I should mention that our entry into the genetics aspect of the business was triggered by an SBIR award of the National Science Foundation. This was our initial entry into applying genetic technology and through it brought us to the attention of the Dow Chemical Co. and this association has led to an investment on their part in excess of $10 million in the company, $5 million of which is in equity and the other remainder is in research agreements.

In summary then I would say, from our perspective, the take home lesson is that if it were not for the availability of Government contract support, Collaborative Research would have never been formed in the first place, and it would never have been able to develop the expertise upon which the company was built, and finally, perhaps fortuitously, we would not have formed the relationship with Dow which has been a key event that triggered the company's entry into the recombinant DNA area.

In conclusion, I would strongly urge that the committee recommend the passage of H.R. 4326. On the basis of our experience and that of many other small, high-technology companies, it is clear that the availability of contract support from Government agencies will spawn the formation of a large number of high-technology companies. While not all of them will be successful, many will, and their success will be an important factor in transforming new scientific advances so abundantly created in American universities into viable, successful, new, and innovative enterprises so critical to the economic well-being of our country.

Thank you for your attention.

Mr. MITCHELL. Thank you very much, both of you.

Here we have a major new big corporation about to come into being simply because there was a governmental grant for research.

Mr. Mason, have you done Government work?

Mr. MASON. Only this NSF work.

Mr. MITCHELL. Have you attempted to do Government work apart from the NSF grant?

Mr. MASON. In a way, but not very satisfactorily.

Mr. MITCHELL. Would you explain that? You said not very satisfactorily. Why?

Mr. MASON. Well, we had a hard time getting anyone to pay attention to such a hair-brained scheme as bringing the Chinese tallow tree in as a new crop. We had a very difficult time.

The NSF grant gave us the legitimacy. Now all manner of people are sending us letters and newspaper articles and that sort of thing. So we are getting a great deal of interest now, but not before.

It was just too, too far out. Too much of a risk.

Mr. MITCHELL. Thank you.

Mr. McDade?

Mr. McDADE. Thank you, Mr. Chairman. I want to thank you both for coming, too, and for your very enlightening testimony.

Mr. Friedman, let me ask you a question, since you have been both places.

I believe your testimony indicates that you were an academic at Harvard and an academic at Brandeis, and that you, during that period of time, did basic research on various governmental interests including the field of, did you say chemistry? Is that your specialty?

Mr. FRIEDMAN. Yes, I was professor of chemistry at Brandeis.

Mr. McDade. And leading toward discovery of a major cancer-fighting drug now used worldwide?

Mr. Friedman. My interest was in applying chemistry to biological and medical problems.

Mr. McDade. You have stated that as a result of some of the excellence of your work as an academic that you were approached to take a very large project on, and that you believed that that was an inappropriate environment in which to do that kind of work.

Would you elaborate on that for me, please, and tell me a little bit about why you felt that way as a professor; was that at Brandeis or Harvard?

Mr. Friedman. No, I was at Brandeis at the time.

Mr. McDade. Professor of chemistry at Brandeis and, because of the excellence of your work, as I understand your testimony, the Cancer Institute or someone came forward with a very large grant that they wanted you to pursue.

I believe your testimony was that you rejected it as an inappropriate forum. Will you tell me more about that, please?

Mr. Friedman. Yes. First of all, I can tell you I had pursued a very highly successful career in academia. At the time I left, I was the author of 100 scientific papers in leading journals. Had I remained in academia, I think that total probably would have gone to about 250 in the interim, since it has been 20 years since I left academia.

I think I was well known, well respected, in fact I believe I had an international reputation in science.

Mr. McDade. I would be grateful if you would forward to the committee a bibliography if you would when you send the testimony down, the materials on which you wrote. It would be helpful to us.

Mr. Friedman. Let me respond to the question.

Mr. McDade. Please.

Mr. Friedman. I will just give you a little background in this. The development of this drug Cyclophosphamide came about through an entirely new approach which we had pioneered. The approach was to use biochemical considerations in the design of drugs, specific drugs for the treatment of cancer.

At that time, that was an entirely novel approach. The feeling at the National Cancer Institute was that not enough work was going on along that particular line, and they came to me and asked me whether I wouldn't expand these activities very substantially.

I told them I had more ideas than I would ever be able to accomplish in a lifetime and I was extremely interested in this.

But, as I said, I didn't think that the university was an appropriate place to do it. First of all, just philosophically, the nature of the work, of the development of new cancer drugs, is not basic research in the sense in which it is conceived in academic circles. It tends to be more developmental in nature. It also requires setting up an organization within the school.

This is not an activity that would involve a few people. It would involve a fairly large group of people. So, I thought the very nature of the work wasn't well attuned to the university, nor was the fact that we were going to organize a program with very well specified and directed objectives.

But beyond that, there were other really quite serious problems in that the way we approached this development involved the crossover of disciplinary lines. It wasn't enough for us to be able to do the chemistry. It had to be coupled with biochemistry, it had to be coupled with pharmacology and other biological studies as well as clinical studies.

It turns out that in the university this is a very difficult thing to do. It is almost impossible to cross departmental lines. You can't organize a program that involves another department. Let me give you a specific example. I had been instrumental at Brandeis in bringing in a very high-grade team of biochemists.

Now, in connection with the work that we were doing, we needed to have very sophisticated entomological studies.

If I went to these people and said, "Now, look, Nate, I am very much interested in this particular enzyme or category of enzymes. We would like to have you people work with us on them," well, his response to me would be, "Go to hell. I have got more things to do that are of fundamental interest to me. I am not going to be involved in a project which is only incidental to my main interest."

In the same sense if they came to me and said, "Orrie, we would like to have a specific chemical substance. It is of great interest to the studies we want to do. Would you synthesize it for us?"

I would tell them the same thing, "I am not a service organization. Of course I am not going to do it." I am involved in pursuing fairly fundamental studies. And, so, that doesn't work well within a university. In a private organization where you hire people, this isn't a concern.

They are hired to do whatever job you hire them for. If you want to focus all the talent, whether it be molecular biology, pharmacology, biochemistry, chemistry, on a particular problem, that is something that is readily done.

So it was for that combination of reasons I felt that the university was an inappropriate place to carry out this work.

Mr. **McDade**. Let me reference another point you made.

You said you felt that you had opened up so many horizons that you had moved a bit from, I suppose what we might agree would be the term basic research, although that term is as elastic as any other phrase in the human language.

But that at the stage you were at, you were at a developmental stage where you wanted to pursue a goal. And that, because of this understandable interest that each participating researcher might have in his own field, you had to move out.

Now, you have heard the discussion here about basic research, in-house research versus private research, et cetera. And indeed there is a question of definition, a very difficult one, a question of what advances the national interest, what advances our technology.

Could you enlighten the committee a bit with your experience and views with respect to that subject? There are those who say, over on the committee that handles health, no small business ought to participate in what is called basic research. What would your view be?

Mr. **Friedman**. Well, the definition of basic research varies depending upon its application. It is interpreted by some as meaning that research which is at the cutting edge of a field, which is involved in producing new understanding and new insights into the area that is being investigated.

There is also, however, a form of research that is hard, often, to distinguish from basic research, which involves fairly basic studies.

The nature of the research isn't so important. In one case, it is the furtherance of knowledge. In another case, you may do work that is quite equivalent and so on, but its objective is to provide the insights and knowledge that will enable you to transform basic knowledge into a practical application.

In the discussion that went on here, I think it would be a mistake if small business were excluded from doing basic research based on the latter definition.

I think there are few small companies, however, which are interested in competing with universities directly in the creation of new knowledge for its own sake.

I think small firms, if they are to survive, have to focus their activities and have to be directed toward a definable practical end.

In some cases, we are doing it now, it is high-grade work, work I think most universities would be happy to carry out, and leads to publications. Our people are encouraged to give papers at meetings and submit papers for publication.

The focus, however, is different.

Mr. **McDade**. I appreciate that distinction very much. I think it is helpful to us as we attempt to understand this.

Mr. Mason, you were nodding your head. Did you want to make a comment as well, either on the definition or——

Mr. **Mason**. Well, no, the definition of basic versus applied is like counting how many angels are on the head of a pin. It is like a theological point of view almost.

It seems to me the difference is, you can make money with one, and the other costs money now, but may make a return at some undefined future. I think that is the difference, time.

Mr. **Friedman**. I would like to make another comment, if I might, in regard to Mr. McCloskey's comments. In a sense, I think they may miss the point. Based on my experience, I would say, any effort from the Government that is directed toward the stimulation of the formation of new businesses I think is a very constructive thing.

This is not to say that everyone of these new businesses is going to become the next IBM. That is not true at all. But I think it is a certainty that a small but significant percentage of these companies will eventually evolve and become major industries.

We, with our extravagant ambitions, hope that one day we will be such, and we will employ many people. In fact, now the company is growing so explosively that we are adding people all the time. I think we create very high-grade jobs.

And so, I think you overlook that at your risk, because the availability of support from Government agencies will stimulate the formation of new companies. They will spring up like mushrooms after a rainstorm.

And you can get involved in the ideology of what is preferential treatment or what is not. But I think in doing so, you may miss the point. I wouldn't belabor all the other reasons why small business should be supported. I think they have been very well described.

Mr. McDADE. Did you want to comment?

Mr. MASON. Yes. We have an engine, I think, ready to run here. We have people working in large organizations and in universities who have a decent idea, which somehow doesn't fit that organization, either because they think it doesn't fit, or because the organization doesn't think it fits.

Those people are going to be looking for an opportunity for funding for those good ideas. And they will be leaving these large organizations and forming new high-tech companies.

I see a real revolution here with such people living in their own home with terminals where they can access all kinds of data from everywhere and from universities. You will have a group of, a large, large group of 1-, 2-, and 10-men companies in a small-cottage industry.

This program can light a fire under that sort of thing, and bring back the really innovative spirit in America. It really can.

Mr. McDADE. I thank you both very much.

Thank you, Mr. Chairman.

Mr. MITCHELL. Mr. Smith.

Mr. CHRISTOPHER SMITH. Thank you, Mr. Chairman.

I won't keep the two gentlemen too long, but first, I want to note I appreciated your comments. Mr. Mason, your emphasis particularly on the risk and entrepreneurial spirit. That certainly does exist.

I think you have really elaborated on that quite well. A question: Perhaps you could expound upon the aspect of that grant that you had received and how it was able to help you attract investors, because I think that is one of the key parts of this legislation.

Mr. MASON. The way this works is that you put together a proposal for the idea you have. You right now perhaps would get a $30,000 grant to put together a program, do a feasibility study to see if the idea looks on paper as though it makes sense.

Then you put in your report on this. Then you have the option of trying for a phase II, which might be upward to $200,000 to do some real benchwork to find out if this really makes sense.

But I was impressed with what NSF did. They didn't just hand out the money, as Mr. McCloskey seems to think. They examined this thing with a fine-tooth comb and they required letters from prospective investors or large companies who thought it was a good idea.

And believe me, that is a tough thing for some fellow in a company to stick his neck out and put on paper, "I think this is a good idea." And if it comes to fruition, if this company really does some good research here, I will put dollars behind it and perhaps we will have a product.

I mean that takes guts. But it wasn't any freewheeling, giving out the money. It was trying to figure out all the ways, making a regular business plan and regular scientific plan that a corporation could evaluate on its own basis.

Following this phase, we are committed to move ahead into a production phase and find money, either by some joint venture or by some investors.

So there will be a lot of jobs and a lot of taxes paid as a result of that pump priming.

Mr. CHRISTOPHER SMITH. I note, in looking at your résumé, that you were born in Trenton, the heart of my district, and I am wondering when you are going to move back, and we both graduated from the same college.

Mr. MASON. Very good. Thank you.

Mr. MITCHELL. You will probably move back, because he is a very persuasive legislator. Gentlemen, thank you both very, very much for your appearance and your testimony.

Our next panel is comprised of Mr. Sheldon Weinig, president of Materials Research Corp.; Mr. Terry E. Bibbens, Electronics Association of California; Dr. Arvid G. Larson, a representative of the Advanced Research & Applications Corp.; Mr. Richard L. DiCicco, president of Technology Catalysts, Inc. of Arlington, Va.; and Marilyn Andrulis, president, Andrulis Research Corp., Bethesda, Md.

Gentlemen, thank you very much for being here, and thank you for your patience in waiting. One of our stellar witnesses, Mr. McCloskey, took a little more time than we assumed he would take, but we are grateful that you did stay to be with us.

Mr. Weinig, will you lead off the testimony, please?

PANEL CONSISTING OF SHELDON WEINIG: TERRY E. BIBBENS; ARVID G. LARSON; RICHARD L. DiCICCO; AND MARILYN ANDRULIS

TESTIMONY OF SHELDON WEINIG, PRESIDENT, MATERIALS RESEARCH CORP., ORANGEBURG, N.Y.

Mr. WEINIG. Thank you, Mr. Chairman.

I am president and chief executive officer of Materials Research Corp., an Amex-listed public corporation headquartered in Orangeburg, N.Y., with plants in Japan, Europe, et cetera.

I founded this after a professorial career. We supply the sophisticated metals and equipment necessary for the production of semiconductors. Our products are found in computers, military radar, satellites, *Columbia* Space Shuttles, just about any place electronics are applied.

I hope they were not in the microphone system in this room.

I also represent the American Business Conference, a group of midrange, high-growth companies chaired by Arthur Levitt, Jr., who was also the chairman of the White House Conference on Small Business, the group which originally recommended the legislation which we are discussing today.

My company is not small business. As its name implies, however, we were originally in the research and development business. In fact, for many years we fought the Government contract battles, and I must say it was not one of the most satisfying periods of my professional life.

In fact, today, the aftertaste is sufficiently strong so that MRC does not actively seek Government contracts for R. & D. despite the fact that the company is engaged in the development and manufacture of high technology projects which are definitely state of the art.

It is quite unfortunate that we didn't have a program like the one we are discussing today 10 years ago as it would have made my life a lot easier and would have certainly accelerated the company's growth and development of innovative technical products.

There are certain aspects of the program being discussed today that I would like to spend a moment on, with your permission.

This country is engaged in economic conflict with many countries, especially Japan. Many feel that MITI, the Japanese Ministry of International Trade and Industry, is the mastermind organization that directs and supports all R. & D. in Japan and is therefore responsible for the Japanese success story.

Well, interestingly enough, our Department of Defense supplies the money for about 66 percent of all the basic research done in this country. So what then—and this is far more than MITI supplies—is this great difference between MITI and DOD?

In essence, one of the most amazing aspects of MITI is that it is very concerned with the ultimate commercial success of those ideas and products it spends its money for its distribution in Japan, whereas the Department of Defense, in its distribution is never concerned with the ultimate commercial success of a product.

And the thing that attracts me about this bill we are discussing today is that it is truly involved with commercial success, the phase I, phase II, phase III, which I think is particularly important, and particularly meaningful and I find of extreme benefit as I look at the overall bill.

Recently, I had the opportunity just about 3 weeks ago to meet with Premier Zenko Suzuki of Japan and Minister Abey of MITI. We discussed some of the things going on in the two countries. One has to quickly agree that one of the great strengths of Japan, of course, is its monolithic nature and the fact they can get their society going in one direction or another, whereas we are a society made up of, oh, what shall we say, a lot of different peoples all going sometimes seemingly in different directions.

Now, we agree there is one great strength in the United States. I must say, sir, that when people begin to annoy me a little with the great success of Japan, the one thing I always fall back on is you just don't have an entrepreneurial society in Japan.

You just don't have this wonderful thing that we have in the United States. I think that is what this bill is all about. It is all about entrepreneurship. It is all about taking an idea and making a buck from it. I think that is where the action is. I guess in a sense I am an old entrepreneur.

I did it some 20-odd years ago, and I run a large corporation today. It was interesting that subsequent to this meeting, the reporters asked me outside of the Prime Minister's residence, is it true that the Japanese managers are better than U.S. managers?

We always go through this same rhetoric, which drives me up the wall. And the answer is there is no question that the Japanese managers have discipline, but the American manager has an unpredictable and sometimes exciting entrepreneurial spirit.

He is disciplined, he leaves the company he is with, starts up another company, leaves professorial position, goes out there in the world. And as far as I am concerned, this is a fundamental strength of this country.

What I would like to say in conclusion, gentlemen, is that let us cater to that elemental strength of this country and make it possible for the entrepreneurs to pursue these ideas that they have.

As far as I am concerned, I urge that this bill be passed without delay.

Thank you.

Mr. MITCHELL. Thank you, sir.

Mr. WEINIG. Mr. Chairman, do I have your permission to leave, sir? I am afraid I am terribly behind.

Mr. MITCHELL. I am afraid we all feel very guilty about that. Do you have questions?

Mr. McDADE. We thank you for coming and presenting your testimony.

Mr. MITCHELL. Mr. Bibbens, you may proceed.

TESTIMONY OF TERRY E. BIBBENS, PAST CHAIRMAN AND DIRECTOR, ELECTRONICS ASSOCIATION OF CALIFORNIA

Mr. BIBBENS. Mr. Chairman, and members of the committee, we are delighted to present the results of a policy that the Electronics Association has provided for you.

A lot of the information I will be talking about is in the testimony, so I am going to give a short summary in the interest of time today.

Just as a quick background of myself, I was founder, past chairman and president of a company called ENTECNA, which we started in 1968, and had about 250 people in 1979 when we sold it.

We provided defense electronics training and simulation equipment which I am proud to say is used to train all the U.S. Forces—Army, Navy, and Air Force—now in the field of electronics, electronics warfare, and to test all the avionics that is now going on the U.S. aircraft to protect our airplanes.

That is quite a track record, I think, for a small company, but we were able to do that because we see a niche the large company I was with wasn't able to fill in time. So we spun off and formed that. In my activity within ENTECNA, I got quite active with the small business organization within my local area of the San Francisco Bay area.

One of them was the Electronics Association of California. Just quickly going through the testimony here today, we believe this is one of the most important business-oriented bills to come before the House, primarily because it fills the gap between the universities and venture capitalists.

We have a lot of good activity going on in the universities and we have a lot of venture capital money. But we do not have something that ties this basic research into something that is commercially viable that the venture capitalists are interested in.

So we feel it is extremely important. We endorse this legislation and respectfully request your support which we know we have here, and are delighted by the sponsorship you have given this bill.

To give you a quick recap of the Electronics Association of California, this association—of which I am a past chairman of the board and past director, and I am now on the executive committee of the board, which is all of the past chairmen—was founded in 1977 in the Bay area, Pete McCloskey's area.

The principal purpose was to satisfy needs that were not being satisfied by other trade associations with small companies. As a measure of our success we have grown to over 500 members in just this 5-year time frame. I would reflect that that is about 70 to 75, maybe 80 percent of the size of the American Electronics Association in California from number of members, and they are a 40-year-old organization.

So we must be doing something right in the 5-year period to have grown that rapidly in their home base, serving a need that they were not serving in the small companies.

We have not been active in legislation up until now. We mostly have focused on services that would provide more cost-effective services for our members. But when this particular bill came up and there started to be some opposition to it, various Members of Congress and their staff called Mr. Conway, our organization president, to ask him what was the Electronics Association's view?

We did not want to take merely the board of directors view, because the board of directors are those people who have been successful enough to now be able to devote some time back to their industry.

They generally do not represent the mainstream, particularly in small growing organizations. So, rather than just taking our board of director's policy, or polling the few members that support them a lot, we decided to go out and poll all of our members.

They asked for a fast response, so he asked for our members to give him response within 10 days. This was the first of February of this year.

Within 10 days, he had responses from a third of the membership—from 150 companies. He sent out a written policy which gave a synopsis of the bill, which presented the pro arguments that were in the House committee report. He presented the opponent's arguments, basically the AEA position, and presented that to all of our members and asked them to write back, signed by the president of the company.

In 10 days, he had 150 responses. Those were 2 to 1 in favor of the bill. It is interesting to note the AEA has come up here before, that of those respondees, approximately one-half of them also were members of AEA.

Of those with joint AEA and EAC membership, the vote was 50–50 for or against the bill. So, we have a lot of support for this in the Silicon Valley. We particularly have the support amongst small companies. Now why, in our analysis of the bill, do we think this is valuable?

Again, I mention it fills the gap between the small companies and funded work of the universities. One of the key things that keeps the venture capital groups from funding innovation is because it can't make money. You cannot make money taking a neat idea and inventing it first.

How you do make money in the venture capital business is taking that idea and bringing it to a product, to the market. Being a venture capitalist, having sold my company, I am one and have been able to work with a number of other people there, I am on the board of a couple, three companies out there, so I am quite familiar with the venture capital mentality including my own.

We only want to invest in something where we can get a 10-to-1 return in 5 years.

That is not with the guy who first has a neat idea. Startup money is still hard to get. Initial seed money is still hard to get. Second round, third round, fourth round is very easy to get now, where there has been a proven management team and so forth.

That is one of the keys of this bill. It allows a guy without a management team, who can't afford the overhead of a facility and staff, to go to the venture capitalist and show his whole management team; it allows him to take an idea from the universities, from basic research, and see if it will come out commercially viable.

Then it fits into the venture capital community. The second reason from my experience of 25 years selling R. & D. to the U.S. military and the Department of Energy when it was AEC, one of the really valuable things you have done with this SBIR activity that has never been done before is that you are allowing industry, in this case specifically small industry, to come to the Federal procurement activities and say, here is a variety of ideas we have.

We would like to propose them to solve our problem. All other Federal procurement is what I call requirement driven. It comes from a requirement from the Army, the Navy, Air Force, and DOE.

It is defined as a requirement that their organization is trying to address. But the way that requirement is defined is by their technical staffs, taking the requirement and defining it in technical terms that go out to bid.

These gentlemen are all experienced program managers, but they are not the latest technologists. The latest technologists are the people out in industry that are answering these.

So, very often these requirements are written in last year's technology. Yet, if you are going to respond, you must respond directly to the RFQ that came out. Again, my experience has shown that an awful lot of times these requests for quotation do not represent what we could do with the latest technology, but we must answer it the way it was written.

So what we are doing is providing the research program on something that is not using the current technology. By allowing through the SBIR program for companies to come in with their own ideas, yet still to address the needs of the organization, you are letting the Government now do something that industry has been doing for years, listen to its suppliers.

The third issue here, is you are allowing a mechanism for small companies to participate in the R. & D. process. The testimony that has been presented has fairly clearly shown the value of the small companies, the efficiency of the small company and innovation of the R. & D. process compared to a large company, the university or even compared to Government activities.

But what hasn't been shown is what is the percent of R. & D. that small companies could do. Now, Congressman McCloskey mentioned Ed Chow's testimony; I took Ed to task back in California on his data and he challenged me to come up with better data.

That was a fair challenge. Just challenging him wasn't enough. I have been working with the BLS now and they are providing me today with a tape which was the basis of the data that Ed Chow used in his testimony; it was the Bureau of Labor Statistics funneled into the NSF.

But what they asked was how many people were employed in R. & D., not how many could be, or how many were available, but how many are employed. Then Ed correlated that with the amount of Government procurement that goes to small companies. Sure enough, there was good correlation. Again, that doesn't address how many were available to do it.

From the preliminary look at the data I just got this morning, it looks like Ed's data is off by a factor of about 10.

Instead of 5 percent of R. & D. scientists being in the small business sector, between 50 and 75 percent of them are in the small business sector of 500 and fewer employees.

I do not have that in final form, but as quickly as I get it I am certainly going to pass it to the committee members because I think it is a very important factor.

Mr. MITCHELL. Ordinarily, I don't do this, but what kind of time frame are you anticipating? Ordinarily, I would not interrupt you.

Mr. BIBBENS. I am hoping to have that this afternoon. It is completed. I am hoping to get the BLS to release it today and pick it up, fly it back, run it in our computer and have the information by the first of next week, Monday or Tuesday.

Mr. MITCHELL. Thank you. Forgive me for interrupting.

Mr. BIBBENS. In the interest, again, of not taking too much of the time here, I would just like to comment on a couple of the suggestions we have to this bill. We happen to agree completely with the Senate bill as passed. We don't have any argument with the 3 percent. But because that has become such a political football and such a large number is being bandied around, we don't really care what the percentage is, but we would really like to see a mandatory bill.

If we have to compromise on anything, we would like to compromise that the percentage go down but the mandatory requirements go across the board. Our reason for that is very simple.

We believe that once the procurement agency starts to use this function, you won't need to mandate a percentage. The results are going to be so damned good that they are going to be using it all the time.

I think NSF has shown that, and I think the DOD voluntary program is starting to show that. It just came out. One of the reasons they like it is instead of just getting one or two proposals for each funding allocation, they are getting 8, 10, 20.

It is one of the best competitive programs and lowest-cost administrative programs I think any of them ever had. There have been questions about how do you minimize the abuse of beltway bandits being set up just to milk this bill?

I think it is self-defeating, anybody trying to do that, because, again, of the competitive environment. But it would be fairly easy to write into this bill a requirement that a repeat company in this cannot have larger than, say, 20 percent of its business based upon this source of income.

If a company can't do more than 80 percent of its business outside of R. & D. funding, it doesn't deserve to be in this program at all. I have a couple of comments which I can either hold to the question and response to your questions, Mr. Chairman, on AEA.

I also have a short rebuttal I would like to give to Congressman McCloskey but I can do that after, too, at your discretion.

Mr. MITCHELL. Please go right ahead.

Mr. BIBBENS. Thank you.

First, on the AEA, it is a 40-year-old organization stated in the Silicon Valley by the Hewletts and Packards, the techtronics of our area, and it is an outstanding organization. It is particularly valuable to me as a person who has been resident in that area all my career because I was able to go to the workshops and hear from the large company experienced personnel how they solve problems.

They have excellent educational workshop programs. It also has done a lot of us a lot of good, for me particularly, by helping us to raise venture capital.

I have an annual seminar in the fall and spring for public and private companies that bring in all the financial analysts. By going to that one spring I was able to get a better price on a convertible debenture.

By the time I went next spring, we had a merger offer we couldn't refuse. I know that would not have happened if it hadn't been for the AEA activity. They have also done some excellent work in legislative activities here, capital gains, R. & D. tax relief and which we are supporting.

But it is dominated by the large organizations. And to kind of help put that into perspective, I would like to just hit three points on that. EAC came from AEA. It was a spin-off. Mr. Conway was solicited to come to AEA in about 1975, I believe, to help set up a small company program for them.

He got very frustrated because he was not able to get the priority and sponsorship within AEA to do that, so after battling this for a couple of years he decided to split away.

In 1977, he founded EAC. He called upon a number of us that had been interested in the small business activity. We came up with the first year's dues in January of that year. He got it started and we started from zero with about six members.

Its focus is entirely small business. In fact, a member with over 500 employees does not get to vote. They do not get to elect a member of the board and do not get to vote on activities.

We have some large members in there, but it is because of the efficiency of the services we provide.

Now, it has grown to over 500 members in just that 5 years. We had 450 when we were testifying back here the first of the year.

We now have over 500, so it looks like we are going to do more this year than our goal of 100 per year. As I mentioned before, we now have about three-quarters the size of members of the AEA and it is a 40-year-old organization.

So, if there wasn't a need for small companies' spokesmen in the electronic technology, we wouldn't be successful. I believe we again represent that group quite well.

Looking at the AEA membership, it has 1,800 members. While it has approximately 1,300 members represented by small companies, an analysis I did in trying to sort out how many engineers were available to do research work, looking at the AEA survey data, wage and salary survey data, only one-quarter of their technical staff is from companies of 500 or under.

Three-quarters of the employee membership is with large companies. Not a single member of the small business services committee is R. & D. oriented. Again, I am stealing from Dr. Larson's testimony.

The third item is that AEA is very, very closely coupled to Stanford and other universities. I am a Stanford graduate, very proud of it. That doesn't mean I agree with everything they do. Particularly I don't agree with some of the administrative structure.

They have a good administration, but I don't agree with their position on this one. As evidence of their active participation with standard, AEA has been very fundamental in helping to raise scholarship funds for the technical students, not only at Stanford but other universities in various States.

They have gotten a very close relationship with the administration of different universities. But again, not with faculty. Looking at some of the letters that have come to Pete McCloskey from Stanford, I saw a number from the department heads. I didn't see any from the faculty endorsing Stanford's opposition to the SBIR.

So quickly, in summary here, AEA hasn't served small companies well or EAC and the other small associations you heard from would not have succeeded as well in growth. They are dominated by large and product-oriented companies, and the close ties to the universities, while they have served the universities and the United States very well in that area, they are not qualified to speak on this particular bill.

They do not represent small companies, they do not represent small companies that are R. & D. oriented which is what this bill is focused on.

I think if you compare their testimony that they have presented in opposition to this bill with their formal testimony on other issues, this is the first time I have seen them come in with what I consider to be bad faculty data, but really good political clout.

I think in this case, they have not represented themselves as well as they should have.

In rebuttal to Mr. McCloskey, and he is in my territory, I feel both qualified and competent to argue with him in this area. One of the things he talked about was there is lots of venture capital about.

Intel is one of the most successful companies that has invested in the microprocessor. It was started by Robert Noyce. Dr. Noyce didn't need any venture capital. He had already become wealthy by being one of the initial founders of Fairchild, and before that, a cofounder with Dr. Shockley with the initial activity there.

This was his third company. He started with his own money and he didn't have to go and get any money for venture capital, and he didn't want to give it away.

He is still the larger shareholder of the organization.

Atari, one of the most successful users, was started by Nolan Bushnell, who started his own company without any venture capital. In the first round he wouldn't let them in. He did get venture capital once he had a product to become successful, to turn the crank.

Nolan Bushnell now has gone on to another thing that we have out on the west coast called Chuck E. Cheese, which is a pizza parlor that has a whole bunch of Atari games. He has set up a very large facility in which he rents out the space and engineering and equipment and that, so the entrepreneurs can start their innovation.

He also recognizes that the innovation doesn't come from venture capital, but guys and sources of funds that help bring ideas, to make it look commercially viable.

Apple, the two gentlemen starting that did that on their own money in a garage sort of thing. They didn't take a penny of venture capital until after they had gotten this thing to be successful in the first place.

I happen to know that case very well, because they were also at the two seminars I attended in Monterey. They presented their company's prospects to the venture capital community, basically saying, "Fellows, we don't need you now. We got our own ideas, and we are going to make it into a commercial product, but if it works, we are going to be back in a couple of years."

Then there is the cost of this program, and Pete is really wrong there. As a businessman, I would vote for this thing, because the administration costs come out something like 5 percent at its worst.

Take the R. & D. costs, the worst case scenario is about 5 percent, and yet the data also shows that the return is at least 4 to 1 and maybe 24 to 1. As a businessman, I will put money into a program that has a 5-percent overhead cost and a four times return.

He talks about an increasing bureaucracy. It does just the opposite.

One of the key things is that SBA will organize a standardized structure that goes across all R. & D. activities, that is common to any R. & D. source, so instead of my having to try to figure out what the DOE forms say and what the Department of Defense forms say, I have one standard form to use across the board.

If the idea isn't liked by one agency, I can go try it at another with the same form. This is really going to help the companies by eliminating the bureaucratic mess.

His last point is that he really finds it objectionable that we small businessmen are coming in here asking for preferential treatment. My initial response to that is unprintable, so I will give you some of the facts here.

The facts, as presented in our own reports here, about 70 percent of the R. & D. goes sole-source. That means that it does not even come out for solicitation in the Commerce Business Daily. We don't even get to see it. It is done behind closed doors. There is no way to get that money.

Over 90 percent of the total R. & D. of our Government is going to large business. We are not asking for preferential treatment. We are asking for just a reasonable shot at showing what we can do on a simplified standardized procedure, and we are actually convinced that if we can get this fair shot, we will show by performance that this is the best way for the Government.

Thank you very much.

[Mr. Bibbens' prepared statement follows:]

PREPARED STATEMENT OF TERRY E. BIBBENS, PAST CHAIRMAN AND DIRECTOR, ELECTRONICS ASSOCIATION OF CALIFORNIA

Mr. Chairman and Members of this distinguished Committee we appreciate the opportunity to present our views, and the results of an industry poll conducted by the Electronics Association of California (EAC), on the bill under consideration.

We believe this is one of the most important business oriented bills to come before the House this year because it fills in the gap between research work at the universities and the commercial development of a marketable product with venture capital. It supports technology and innovation in a way that will help U.S. business become even more competitive in the world market, and it also provides a new mechanism to allow the U.S. Government the ability to draw from a much broader base of technology.

We endorse this legislation and respectfully request your active support. To the best of our knowledge we are the only industry trade association that has solicited the views of its entire membership regarding this proposed legislation. The Electronics Association of California members voted two to one in favor of the bill.

Now to provide a basis for you to weigh the merits of our testimony, we would like to provide a brief background on the Electronics Association of California (EAC).

The Electronics Association of California was founded in 1977 for the purpose of helping firms leverage their collective strength to develop new employee and management services which are important to their individual companies. Since that time, approximately 500 high-technology firms have joined the EAC making it the fastest growing trade association serving the electronics industry.

Earlier this year, we polled our full membership on this issue in preparation for testimony before another House committee. In less than 10 days, we received written responses from one-third of our members. The survey reflected an almost two to one edge (65 percent) in support of this bill. Based on this direct solicitation of our members, the EAC Board of Directors unanimously voted to support this legislation. As mentioned earlier, we believe that this direct survey represents the only industry poll on this matter of the high-technology industry, and we feel confident in stating that it accurately represents the belief of small and medium-sized high-technology companies in California.

We would like to comment on the reasons we find this bill attractive and some recommendations for consideration.

In our opinion, this bill fills three very vital holes in our current system:

(1) It fills the gap for small companies and technical entrepreneurs between the funded research work of universities and the commercial exploitation of a product by the venture capital community. The universities are the front of our technical wedge, but appropriately are not involved in the commercial marketing of products.

The venture capitalists provide the mechanism to take a commercially viable product to a market, but their requirements are for demonstrated capability and feasibility, and a full-fledged management team that is capable of providing them with their desired 10 times return in three to five years. Through the courageous legislation of the past few years in tax reform, we now have adequate venture capital to take these teams forward, and a viable new issue public market to accept the successful mature companies. What was missing was the feasibility development that is addressed by this bill.

This program provides funded support for: "(A) a first phase for determining, insofar as possible, the scientific and technical merit and feasibility of ideas submitted pursuant to SBIR program solicitations; (B) a second phase to further develop the proposed ideas to meet the particular program needs; and (C) where appropriate, a third phase in which non-Federal capital pursues commercial applications."

These first two phases provide a very effective means to bridge this gap and yet allow for competitive procurement of the most promising ideas for the benefit of the procuring agency.

(2) By the mechanism of the SBIR program you are providing an excellent means to stimulate the Government R&D management activities to utilize the latest technology available from industry. You have structured a supplier driven procurement concept with a small percentage of the funds. This allows industry to present their best ideas and requires the federal agencies to look at these and select the ones that best fit their charters.

The vast majority of other federal R&D is requirement driven. The solicitation by the federal agency is based on their technical staff's translation of the operational requirements into a technical requirement. The bidders must respond to this solicitation even if the requirement does not utilize the latest technology. My personal experience has show that at least 10 percent of the solicitations were written in this manner. We cannot blame the government engineer, because he has become a program manager, not a technologist. With the dynamic advances in technology in our industries, it is natural to find pockets of technology that are beyond the requirements stated in the solicitation. You have provided a means to have this technology presented to them by small businesses and yet, still retain the competitive procurement process.

(3) Lastly, you have provided a mechanism to increase the participation of small business in the R&D process. The Small Business Committee report has clearly documented the position that small businesses are highly productive in the innovation and technology areas and shows that: (1) small firms with up to 1,000 employees produce about 24 times as many major innovations per R&D dollar as large firms with over 10,000 employees, and four times as many as medium-sized firms, and that (2) the ratio of innovations to sales is one-third greater in small, high-technology firms than in their counterparts.

What has been less clear is the degree of participation of small firms in the R&D process. The charge by some opponents of this bill, in testimony before the House Science and Technology Committee, that small business gets its fair share because it has a very limited number of scientists and engineers to perform R&D work is incorrect. They have cited the National Science Foundation study that shows only 31,900 "Full-time-equivalent number of R&D scientists and engineers" in all the companies in the U.S. with less than 1,000 employees. This represents 5.5 percent of the total number of R&D scientists in the private sector (576,000). Further, they cite that since the Federal Procurement Data Center shows that 6.8 percent of federal procurement dollars for R&D went to small businesses, they are receiving their fair share.

It is our position that using this data for the question asked is erroneous. The NSF study was based on data obtained from the Bureau of Labor Statistics Division of Periodic Employment Statistics Programs using the Occupational Employment Survey. This form asks the surveyed companies how many engineers and scientists are currently performing R&D work. It doesn't ask how many are available, or how many could perform if funding was available. Therefore, it is my opinion that this data used for this question is a case of drinking our own bath water. We asked how many were employed, and we verified with procurement data.

As a cross correlation of the invalid nature of this data, we reviewed the 1981 salary data from a national electronics trade association representing both large and small companies in the U.S. They showed over 16,000 engineers alone for their companies with less than 500 employees and only 55 percent of their members participated in the survey, and they didn't include scientists and technicians covered by the NSF data. Their survey would show that the electronics industry alone would more than absorb all the NSF R&D personnel, and that leaves no room for the biomedical, chemical, physics, optical, and other fields. We believe the House reports that show the R&D agencies are underutilizing the small, high-technology companies are correct.

Experience has shown that there are many very real barriers to small companies that have caused this underutilization. We believe your bill solves the vast majority of them by simplifying and standardizing the solicitation by forcing a review of small business offerings, yet it provides for selection of the best programs via the competitive procurement process.

We would now like to offer the following for consideration in implementing the legislation:

(1) S. 881 calls for 1 percent set-aside annually while H.R. 4326 calls for a set-aside starting the first year at 0.5 percent with annual increases reaching 3 percent in 1986. We realize the House and Senate will eventually have to reach agreement on the amount of dollars to be allocated for this program and the 1 percent level seems appropriate to us at this time. Tied to the dollar allocation should be a periodic congressional review of the legislation to insure that the initial objectives are being accomplished.

(2) To minimize abuses of the program, we might suggest that SBIR contracts be limited to a small percentage of a firm's total sales (i.e., 20 percent for on-going businesses). Further, we recommend that firms be limited to 10 percent of the funds of any one funding agency.

(3) It is important that effective implementation of this legislation not be hindered by undue government regulations. Innovation requires flexibility more so than production contracts. This must be recognized by the program administrators if we are to realize maximum innovation and technological advancement from the legislation.

(4) Government paperwork, desire to over-control, added bureaucracy and inefficient administration were the major reasons cited by companies opposing this bill. Since this program is intended to foster development, we recommend the contract reporting mechanism focus on progress of the work and minimize ancillary reports.

We understand the concern of the universities regarding the inclusion of "Basic Research" funds in this program since these funds generally are directed toward capital intensive organizations, such as universities, and small company contribution is less obvious here. These "Basic Research" funds represent a small percentage of the R. & D. budget but are highly leveraged in these institutions. We believe that basic research should not be curtailed by this legislation. We don't want to be in the position of eating our seed corn. In fact, we feel the U.S. should be planting more to regain our momentum in the world market.

We believe you have an excellent program in this legislation. It interfaces well with other legislation that provides more incentives for successful small companies and yet ensures against abuses by those that will try to abuse any system. You have provided the incentive, funding and competitive procurement that will ensure the best ideas surface, yet you have provided the environment for the government employees to allow them the freedom of choice without personal risk, and you have kept the purchasing decisions within the agencies that have to solve the requirements directed by their charters. You have filled a needed void between the universities basic research work and the venture capital monies now available. You have utilized the experience of the NSF programs and yet retained the existing procurement channels, thereby minimizing the cost of administration. It is our belief that the commercial successes of this program will result in an increased tax revenue that will more than pay the administration costs.

We urge the passage of this bill and respectfully urge the passage of a bill with mandatory requirements. Any voluntary program would not result in action based on past experience. Thank you very much for your courtesy and time. We appreciate your continuing efforts on behalf of better and more responsive government.

Mr. **Mitchell.** Thank you, sir.

I do have some questions.

Dr. Larson.

STATEMENT OF ARVID G. LARSON, DIVISION MANAGER, ADVANCED RESEARCH & APPLICATIONS CORP., SUNNYVALE, CALIF.

Mr. **Larson.** Thank you, Mr. Chairman, and committee members.

I would like to offer a statement for the record which I believe you have, and I will briefly review the high points.

My name is Dr. Arvid G. Larson, division manager of the Advanced Research & Applications Corp., and we are a small business, high technology firm located in Congressman McCloskey's district.

My personal background is a doctorate from Stanford University and on the staff of their Research Institute for over 10 years. I have lived in Congressman McCloskey's district for the bulk of my adult life and supported him in most of his elections.

My appearance today is as a spokesman for our company, its president, Dr. Robert Armistead, members of our technical staff, certain members of the American Electronic Association and the Electronics Association of California, and many other members of our high-technology electronics industry in support of the Small Business Innovation Research Act, H.R. 4326.

My statement today will consist of a brief overview of Aracor and our advanced technology contract R. & D. programs as representative of the small business R. & D. community serving the Department of Defense and other Federal agencies, followed by our views of the National Science Foundation Small Business Innovation Research and the Defense Small Business Advanced Technology programs as representative of a small business R. & D. programmatic methodology similar in approach to that contained in H.R. 4326.

These views are given as a current participant in both programs, in that Aracor has won two of the 86 fiscal year 1982 phase I SBIR awards and one of the 87 fiscal year 1982 phase I DESAT awards.

Aracor is a small company, founded in 1976 and could be characterized as a spinoff of Stanford Research Institute.

We are located in Sunnyvale, Calif., with a branch office in the Washington, D.C. area, and now employ a permanent staff of nearly 50 people. Over 50 percent of our staff possess a master's degree or a doctorate degree in the physical sciences and the engineering fields. Our principal fields of interest are radiation physics, solid-state semiconductor, and large-scale integrated circuit electronics, and computer-based systems technology, and we feel we maintain a state-of-the-art capability in these rapidly evolving and increasingly important fields.

Most of our work is R. & D. work supported by the Federal Government, and most by the Department of Defense. We have over two dozen of Federal R. & D. contracts, including several sponsored by the Defense Advanced Research Projects Agency, and several of our projects, I might add, are in the very high-speed integrated circuit program of the DOD, and we are very proud of our participation, although we are not a prime contractor. That seems to be restricted to the large business community.

I point out these facts simply to illustrate that as opposed to many other members of the AEA and EAC, we are not specifically devoted to the electronic product sales or commercial accounts.

Rather, we pride ourselves on our specialized scientific expertise and our R. & D. achievements which we have been able to competitively and successfully apply to a number of Government R. & D. programs.

We feel that our company and our other small firms are able to provide the cutting edge of the innovative technical capability which we feel is vital to address many of our country's most pressing defense, energy and other similar high-technology requirements.

However, I do not advocate that Federal R. & D. funds should be spent on activities for which technologically oriented small business firms may be unsuited. For example, ARACOR could not contract to build the B-1 bomber or the Trident submarine, although we do feel that there are billions of dollars of noncompetitive R. & D. contracts announced during any year in the Commerce Business Daily in the range of $50,000 to $500,000 awarded to Lockheed, TRW, IBM, and other large defense contractors which we believe ARACOR, as well as many of our fellow firms in the high-technology small business community, could do, especially if we had the Government-furnished equipment that these large firms often use in pursuit of their R. & D. activities.

A variety of studies have been cited this morning, and in past testimony, that shows that small business can be a valuable and productive source of innovative and advanced technology.

This small business is typically led by a cadre of dedicated and motivated entrepreneurs who are willing to undertake the high-risk venture required for the transition from promising and yet unfulfilled research to practical application.

This is where we come in. In our experience, we found that such dedication and motivation alone are not usually enough. What you do need is the availability of risk capital to both nurture and sustain this innovative enterprise.

To refute Congressman McCloskey, our experience is that most venture capital is primarily available to companies that can develop and sell products, and especially not available to firms that principally conduct contract R. & D. for the Government.

To contract, research and development-oriented firms such as Aracor, risk capital is largely unavailable, because investors tend to worry about the security of their investment in a firm whose primary asset is people.

Now, speaking as a current participant in both the SBIR and the DESAT programs, and admittedly with a certain vested interest, we feel that each of these programs are achieving their goals toward encouraging the development and application of high-risk innovative technology to specific Government-defined program areas.

These, of course, are competitive programs.

In most cases, the limited phase I and phase II contract research support which the NSF and the DOD programs, do not really produce a total solution necessary to meet critical Government or industry technology programs or problems.

We feel the ultimate goal of most participants in the two programs is to establish and prove the utility and the attractiveness of their innovations sufficient to interest outside venture capital, or to encourage partial support from a large Government contractor organization.

Now, just by example, Aracor has been approached within the last year by several large defense contractors, relative to developments that we have in our NSF and DESAT programs, for application to military problem areas.

We feel these are potentially high-payoff, but high-risk innovations that will improve or be of value to industrial productivity improvement, as well as to defense system production technology; and these programs might not otherwise have been considered by these large contractors.

We feel that the SBIR and the DESAT programs are compelling demonstrations of the potential achievable from a programmatic approach toward giving small business a more equal footing in competing with large business in order that innovative capability can be best directed toward solving national problems.

Since the ensuing awards should result from the competitive bidding process, we feel the approach should permit the more capable small business firms to be primarily involved, rather than serving to establish just another set-aside subsidy for firms otherwise unable to compete for Federal R. & D. contracts.

This statement has been made several times, and the emphasis here is that it is a competitive program. It is not just a giveaway.

We are full-fledged members of the American electronics industrial community, and certainly have close working ties to the academic community. We are both shocked and distressed at the variety and the rationale of the opposition to the Small Business Innovation Research Act.

Much of the data and many of the facts provided in opposition to the proposed legislation which I have personally seen and heard this morning just seem completely distorted, and suggest an overall lack of familiarity with the process of Government R. & D. contracting, as well as with the objectives of the proposed legislation.

I would like to cite one example, and this is the opposition of the American Electronics Association membership to the bill. In reality, this opposition is the recommendation of an 11-member Small Business Services Committee of the AEA which is endorsed by the large business-dominated AEA board of directors.

The general AEA membership composed of over 1,200 member firms, has had no voice in the establishment of this position.

It is also of interest that not one of the 11 firms represented in the AEA Small Business Services Committee actually conducts research and development as a line of business.

Now, led by Dr. Robert Armistead, the president of Advanced Research & Applications Corp., a letter expressing support for this bill has been generated from senior executives of 14 high-technology small businesses, all of which do belong to the AEA, and all of which do represent portions of the AEA membership, which do conduct R. & D. as a line of business.

I have a copy of this letter with me. I would request that you enter it into the record. Incidentally, Congressman Bedell had it inserted into the Congressional Record.

Mr. MITCHELL. So ordered.

[The letter referred to above follows:]

April 22, 1982.

The Honorable Berkley Bedell
United States House of Representatives
B-363 Rayburn Office Building
Washington, D.C. 20515

Dear Mr. Bedell:

The undersigned are all senior executives of high-technology small businesses which belong to the American Electronics Association (AEA). We feel that way too much has been made of the AEA opposition to H.R.4326 and S.881. In reality, the opposition is the recommendation of the AEA's eleven-member Small Business Services Committee, endorsed by the large-business-dominated AEA Board. The general AEA membership, composed of over 1200 member firms, has had no voice in the establishment of this position.

The "voice" of those eleven members has been widely disseminated. Thus, I hope that you will assist us in having our position noted to a like degree, for we are AEA members and number more than eleven.

It should be of interest to consider that not one of the firms represented on the Small Business Services Committee (SBSC) conducts R&D as a line of business. In fact, it was originally thought that none of the SBSC had ever had personal experience with a government R&D contract, but Mr. Ken Hagerty, AEA's political lobbyist, informed us that one member had participated in one contract.

It has been contended in numerous articles that 80% of the AEA membership are small businesses and "exactly the kind of firm that this legislation would effect." This statement is largely untrue. A majority of the small business members of the AEA are product-oriented firms that do not seek R&D contracts. In turn, the R&D-oriented firms which would be affected by this legislation are basically unaffected by R&D tax credits.

The AEA has taken the tack of relating the Innovation Research Act to the controversial 8(a) program and warning of waste, abuse, the development of dependence by participating firms, as well as other dire happenings. Instead, we choose to believe that the intent of the bill will be served, that is that the demonstrated creativity and innovative capabilities of small firms will be more readily directed to problems of national concern.

We, the undersigned, are definitely against waste and abuse, who isn't? However, we are in favor of the creative solution to pressing national problems and would like to have an improved opportunity to contribute our ideas and R&D efforts.

We applaud your efforts to pass legislation that has this as its goal and know that you will dilligently seek to build in safeguards that would prevent the problems that the AEA has presupposed.

Sincerely yours,

B.C. Armstead, President AMCOE
[illegible], ITEK
[illegible]
[illegible], Quantic
D. P. Crane, Altus
Ned S. [illegible], [illegible] Associates
Vernon H. Blackman, S-Cubed

Glen Swenson, ILC Technology
Walter Nelson, Crystal Technology
Kenneth R. [illegible], Western Microwave
Jose R. [illegible], SBA Sideband
Lawrence Weikart, Tri-Data
M. L. Hayes, Jr. [illegible] Laboratories, Inc.
J.J. Spilker Jr., Stanford Telecommunications

Mr. LARSON [continuing]. In summary, based on first-hand experience, we feel that the proposed Small Business Innovation Research Act or some other form of Government support is the only way to give a high-risk, high-payoff idea important to defined national needs a chance of reaching fruition, especially one that involves research rather than product development.

Moreover, especially in defense and possibly some of the energy research needs, there is a very limited market potential for some of the initial research. Many of these needs are, therefore, not otherwise to be addressed by the venture capital initiative which desires a quick investment satisfaction, nor by the relatively short-term and bottom line profitability-oriented large business concerns.

We feel such initial support and nourishment of selected technologically-risky ideas during this transition phase of conceptual promise to practical application are essential to assist the national defense and other similar innovative-technology-dependent problem areas.

We do not feel the proposed legislation is just another level of special procurement treatment for one segment of the business community, and is thus against the free market ideology which we fully support.

We do not feel the proposed legislation will create another set-aside program with resultant corruption, inefficiency and regulatory restriction if the subsequent innovative technology programs are properly administered, if they address well-defined Government needs, if they are competitively awarded, and if they follow the general operating philosophy of the existing and very successful small business innovative research and the Department of Defense and DESAT programs.

In closing, Mr. Chairman, let me state we view the proposed legislation as a set-aside for the Federal research and development establishment serving to meet the intent of encouraging national technical advantage, innovation and productivity growth which is so vital to our critical national interests.

We feel H.R. 4326 is a fair and adequate approach to meet national high-risk, high-payoff technology needs.

Thank you, Mr. Chairman.

Mr. MITCHELL. Thank you, sir.

We will come right to you next, but I see one of our witnesses has shown up, Mrs. Andrulis.

TESTIMONY OF RICHARD L. DiCICCO, PRESIDENT, TECHNOLOGY CATALYST, INC., ARLINGTON, VA.

Mr. DICICCO. My testimony is directed toward the amendment to the proposed bill, H.R. 4326, which would exempt the National Institutes of Health from establishing an SBIR program.

As background for this testimony, our company has been operating for 3 years, in the business of matching up the R. & D. needs of large companies with small high-technology research firms. We have over 400 medium to large clients who retain us to find technology available for license. In order to accomplish this, we developed a data base of small R. & D. companies, which we update twice a year.

The only information we collect is how much they are spending in R. & D. by project. This serves as the basis of possible proprietary technology, and our job is to find it. We now have data on 9,613 small high-technology research firms in the United States.

One of the major reasons given by those in favor of exemption is that there are not enough small firms in the United States that can perform research in the life sciences. I have brought with me our firm's proprietary computer file which contains information on the research activities of small high-technology firms in the United States.

A breakdown of the areas in which they are performing research in the life sciences is as follows. I won't read all of them, but there are, for example, 168 doing basic research in cancer.

The total shows 2,636 small high-technology firms doing biomedical research in the United States.

[List referred to above follows:]

Biomedical small high-technology research companies in the United States

Subject area:	*Firms*
Biomedical engineering	144
Biochemistry	162
Pure cancer research	168
Cell biology	164
Genetics	173
Immunology	206
Medical electronics and instruments	211
Molecular biology	180
Nutrition	157
Pharmacology	295
Recombinant DNA	109
Toxicology	195
Tumors	55
Virology	198
Other categories	219
Total	2,636

Source: Technology Catalyst, Inc.

Mr. DiCicco. In comparison with this list, the NIH has sent us their list of small businesses receiving R. & D. contracts of $50,000 or more during 1979–82. The total number of firms on the NIH list is 93.

It would appear that NIH is not making any significant effort to identify small firms in the United States that can perform research in the life sciences. Our list has been compiled in the last 3 years. We estimate an equal number of small life sciences R. & D. firms exist which are not yet in our files. Mr. Stephen Turner, president of Bethesda Research Labs, stated that there are 1,000 research firms working in one life sciences category: Cloning. Using Mr. Turner's number, this brings the number of life science high-technology firms to over 3,500.

Although our firm has been in existence for three years, we have observed technological trends involving small high-technology firms. In the 1960's, mechanical engineering dominated the technology scene. In the 1970's, computers and microelectronics were the trend. Now, in the 1980's, we see genetic engineering, cancer research and medical diagnostics involving more small firms than ever before. We expect the technological trend of the domination of life sciences continuing throughout the 1980's.

NIH's second reason for requesting exemption is their assessment that small firms cannot perform the same quality of basic research as universities and other nonprofit institutions. We also have some facts to place this into perspective.

On April 6-8, 1982, Technology Catalysts sponsored a trade fair, which included the small firms submitting proposals to the National Science Foundation's SBIR program, in which the Life Sciences category accounted for 35 percent of the entire fair.

Also invited were those small businesses on the NIH list. The results were revealing on the question of research quality. Consider the following selected NIH R. & D. awards made to small business over the last 3 years:

One, repair, restore and rebind rare books.

Two, provide a generator and other equipment for the National Library of Medicine.

Three, catalog monographs in English and foreign languages; and my favorite.

Four, remove existing elevated access flooring.

Mr. MITCHELL. You have to be kidding.

Mr. DICICCO. I would like to inform this committee that we do not consider these awards to be research and development projects.

Now, consider 5 of the presentations made by NSF SBIR proposal submitters at the trade fair, seeking private-sector support:

One, poroplastic for transdermal drug delivery.

Two, laser-based photoacoustic methods for measuring stable isotope ratios.

Three, in vitro detection of allergy-using immunofluorescence.

Four, effects of processing technology on the reduction of cholesterol and lipids.

Five, new genetically engineered microbes.

At the trade fair, the SBIR firms in life sciences not only outnumbered the NIH firms 20 to 1, but the SBIR quality of proposed research was superior. Firms on the NIH list are not given the opportunity to perform the same quality of research as universities and other nonprofits, and we have seen them unable to seek private-sector support in the marketplace for contract research.

The key to furthering job creation and medical research breakthroughs is H.R. 4326, without the amendment exempting NIH, because it will draw small firms to submit proposals for the research they can perform. Once an SBIR program is announced at NIH, the list of 93 life science firms interested in submitting proposals will grow dramatically. In my opinion, a minimum of 3,500 small life sciences firms exist in the country today capable of doing quality R. & D.

Under the Senate-passed version of the innovation bill, NIH would have to spend less than $30 million by the time the program is operational in 3 years. That means 60 contracts to small firms. We believe that out of 3,500 small life sciences R. & D. firms in the United States, there is a sufficient number to submit proposals for the 60 awards.

One of the NSF/SBIR life sciences firms at the trade fair, SISA, Inc., was voted by Scripps—a well-known international pharmaceutical industry gatekeeper—as among the 100 top R. & D. firms in life sciences worldwide.

You are well aware of the rapid stride in genetic engineering and the leading role which small firms have played in moving basic research into advanced applications areas. It is almost a tragedy that for 20 years, NIH has prevented small life sciences firms from even submitting research proposals to them. These small firms pay taxes to support such research, but are not encouraged to submit their research proposals, based on false grounds that a sufficient number of small life sciences firms do not exist, and those that do exist are not able to perform quality research.

These premises are simply not true.

It is our opinion that the small R. & D. firms in the life sciences field is virtually exploding in quantity of firms and quality of research. An opportunity for these small firms to participate in NIH research would be of great benefit to the Nation.

Mr. MITCHELL. Thank you for very excellent testimony.

Dr. Andrulis?

TESTIMONY OF MARILYN ANDRULIS, PRESIDENT, ANDRULIS RESEARCH CORP., BETHESDA, MD.

Ms. ANDRULIS. My brief presentation is divided into three parts.

First, I would like to establish the credentials and standing of my firm in the research community. Second, I would like to address the problem areas we face, and third, I would like to raise certain questions.

My name is Dr. Marilyn Andrulis. I hold a Ph. D. in Mechanical Engineering/Engineering Acoustics.

As the president, chief executive officer, and majority owner of a high-technology research and manufacturing small business, it is my pleasure to have been invited to testify before your committee today on the need for the Small Business Innovation Research Act of 1982 being passed in its entirety.

My company, the Andrulis Research Corp., founded 11 years ago as a Federal contractor, is headquartered in Bethesda, Md., has a fully equipped chemical research and products laboratories in the District.

Andrulis is highly diversified with extensive corporate experience and capability in defense, space, biomedical and educational research, systems, and services. Fiscal year 1982 sales will approach $2.5 million.

I plan to highlight some examples of our federally funded research projects, for the purpose of characterizing the range of the Andrulis creativity and scientific skills, and then to focus on the total impenetrability of the biomedical research program at the National Institutes of Health.

Andrulis is proud to have been one of the 90 competitively selected recipients of a fiscal year 1981 National Science Foundation small business innovation research program award.

Our winning grant application is entitled, "Hybrid-Phase Catalysts for the Oxidation of Phenol to Benzoquinone." It is designed to apply the automotive catalytic converter concept, that is, a moving stream across a fixed catalyst, to the industrial scale conversion of raw chemical feedstock to expensive chemical intermediates at one-tenth the cost. Preliminary results look extremely promising. We have already been approached by large chemical companies interested in commercial applications.

Based on preliminary results, we have already been approached by large chemical companies.

Design of protective clothing: Under sponsorship of the U.S. Army, Andrulis has studied novel approaches and designed and developed catalysts for use in creating protective clothing to repetitively inactivate chemical warfare agents and then regenerate for reuse. Here, too, results are promising.

Officer assignment decision support system: Under U.S. Marine Corps funding, Andrulis designed and developed a sophisticated computerized system for the worldwide assignment of all USMC officers.

Andrulis' system employs unique real-time computational techniques based on innovative concepts in gaming theory in order to provide optimum assignment recommendations to achieve specified objectives.

State of the art, special purpose polymers: Under U.S. Air Force contract, Andrulis is conducting exploratory development of a low-cost, heat- and fuel-resistant sealant. Andrulis is evaluating the cost effectiveness of various syntheses for producing a monomer, with the goal of reducing its production costs by a factor of 10.

But these research contracts are the exception, not the rule. Of all of the many agencies from whom we have sought business, none has been more closed to research funding than that of the National Institutes of Health.

There are four fundamental reasons, the interlocking nature of which works to exclude small business from access to the NIH research community.

First, the massive NIH-university contracting complex: NIH awards over 85 percent of all its contracts to universities, institutes, and big business. With NIH's use of grants as the primary funding mechanism, what little research is contracted, small business must scratch and claw after against these entrenched institutional behemoths.

Second, the PHS grant: A 100-percent set-aside of virtually all research funds to universities, hospitals, and other nonprofits: The major path for research funding, grants to universities and nonprofits only, with peer reviews performed solely by inhabitants of these institutions, totally locks out small business from NIH research funding.

To show just how exclusionary this is on the one hand, yet how viable are small business research ideas on the other, my business partner had to set up a nonprofit solely to act as a vehicle for our staff's research ideas. Two of their first three PHS research proposals on drug addiction mechanisms and anticancer drug design were funded and resulted in important scientific results.

Third, NIH funding regulations virtually prohibit unsolicited proposals: Unlike almost every other agency, NIH regulations on funding unsolicited proposals are so exclusionary that it is literally impossible to obtain funding by this route.

For example, one requirement states that it must be proven that no one else has this same concept and/or could fulfill it better. The only proof acceptable is openly soliciting competitive proposals on the concept or its objective, a perfect catch-22.

Fourth, institutional resistance: Even though we have carefully and assiduously tried to establish novel small business contract techniques at NIH, such as precontractual Source Soughts, followed by SBSA. If qualified SB are found, we have met consistently with active and passive resistance.

The NIH attitude has been characterized by more than one high NIH official in a total unwillingness to get into disruptive and unproductive arguments with program officials and scientists about how their work should be contracted.

One senior NIH administrator characterized NIH scientists as feeling they were doing the public a favor "donating" their time and talent and that the public was unappreciative of these Nobel-laureates-in-waiting.

As long ago as 1978, I met with senior NIH administrators to work out practical procedures for implementing 8(a) set-asides. To date, their carefully spelled-out plan has not, to our knowledge, been implemented or enforced.

I share as an example a case. SBA has assigned a PCR to DHHS who is aggressive, creative, knowledgeable—as a former CO—and diplomatic. NIH has responded with new tactics of delay and changed ground rules.

Carefully negotiated SBSA or Sources Soughts have last-minute changes in contractual requirements. One requirement whose SBSA interested us, to review and evaluate the R. & D. of interferon and other biological response modifiers, was solicited in April 1981, canceled and readied for resolicitation 12 months later.

The SBA PCR was given 96 hours to get SB credentials forward which, in our case, were never received and/or read and which led to the conclusion we were not qualified. What makes these experiences most striking is that none of this relates to the more exotic and important subject of research, but on supporting services, which could be contracted to any qualified SB.

The literal crime of all this in our particular case is that whereas we have been the major supplier to NCI of the second largest selling anticancer drug in the world, cis-platinum; and, whereas Andrulis has been joined by the inventor of one of its successors now showing some near-miraculous results in clinical trials on terminal cancer patients; and, whereas we have scratched and clawed and scraped up enough internal funds to make five more platinum compounds and found every single one active in first tests, we not only cannot approach NIH for contract research funding of this, but that NIH doesn't even have the mechanism to fund us if it wanted to.

Instead, we have sought out basic research funding halfway around the world because another country sees this work to be in its best scientific, health, and economic interests.

If this committee wishes a striking example of the unproductive I ask them to ask their colleagues who oppose this bill why small business cancer research can't be funded down the street in Bethesda and what this could mean to the health of their constituents, their friends, and their family? Nature and results of opposition to the passage of this bill without exemptions.

The political argument presented to those committees overseeing the agencies with the major R. & D. budgets is that to set aside as little as 1 percent of the respective R. & D. budgets would result in diminished quality of the basic research in the United States of America.

This argument, seeking to exempt certain key R. & D. budgets such as NIH's, evidences no proof that it will undermine quality of basic research, but it will undermine free enterprise, the cornerstone of democracy.

For the truth is that the contributions of high-technology small business to innovations have been nothing short of spectacular.

According to an NSF study, "Of the leading 500 technological innovations in the United States between 1953 and 1973, small firms, defined as those with up to 1,000 employees, produced four times as many innovations per research and development dollar as medium-sized firms."

So then, what if the collective voice of larger universities, medical schools, Government laboratories and large companies say, "Do not set even 1 percent aside for high-technology small businesses because the quality of research will be lessened?"

The intensity of the political pressures surrounding this offensive and shallow rhetoric should signal the obvious solution: Test the hypothesis. Let the high-technology small businesses have the opportunity to demonstrate by passing the unamended Small Business Innovation Research Act with a review provision and then measure not only the quality of performance, but measure what Milton Stewart of Inc. Magazine refers to as the "built-in payoff to the taxpayers" by comparing the "Federal seed money" to the "follow-on private money" rendered for commercialization.

There is no mystery surrounding resistance to the SBIR Act. High-technology firms are more willing to compete for Federal R. & D. funding than any of the recipients of the current "preferred 'de facto quotas'" now in place for Government laboratories, nonprofit academic centers, and large business.

Mr. Mitchell. Thank you, and thank you, all of the panelists. It has been just devastatingly good, from our position. It was excellent. I was sorry I burst into your testimony. It was so ludicrous.

Rare bookbinding?

Mr. DiCicco. Yes.

Mr. Mitchell. I think it was in December I visited in Palo Alto with the chief executive officers of about 25 companies. The meeting ostensibly was called to discuss changes in legislation which we got to discussing.

Then, the president of Stanford suggested opposition to this legislation, which was not on the agenda, and went on to point out that small businesses were already benefiting significantly without benefit of the legislation.

I was amazed that half the CO's around the table immediately shook their head and said, "No, that is simply not true." I wanted that to be in the record.

There is one thing that really disturbed me quite a bit. That is in your testimony, Mr. Bibbens. That is your statement that the procurement is put out by the various agencies based upon what might really be obsolete technological information.

It seems to me that borders on being criminal. There is no way you can make significant breakthroughs for the Government and our Nation if the procurement process itself is not up-to-date with the new technological advances.

You have been kind enough to say you will send me something. I will request one more thing. Would you send me as quickly as you can two or three specific illustrations of this kind of procurement request?

Mr. **BIBBENS**. Yes, sir.

Mr. **MITCHELL**. I have no further questions. I just am personally, and as chairman of the committee, and I think I speak for all the members, really, really grateful. This has been excellent testimony.

Mr. McDade.

Mr. **MCDADE**. Thank you very much, Mr. Chairman.

And thank all of you for coming and presenting this testimony before the committee. You have probably all seen the litany of editorials that have appeared from the New York Times, the Washington Post, L.A. Times, Denver Post.

Really, they all pretty much say the same thing, for example, that the association most likely to benefit, the American Electronics Association, opposes the bill. Now you have hit on that in your testimony. Let me just clear up a couple of points, if we can.

You statement is that, first of all, the national association never polled its membership. Is that correct?

Mr. **BIBBENS**. That is correct.

Mr. **MCDADE**. Your statement is that in California, where at least two of the participants at the table have earned their living in high-tech organizations, you were forced to spin off and form an independent organization, and you did poll your membership.

Mr. **BIBBENS**. That is correct.

Mr. **MCDADE**. The poll showed a positive response of 2 to 1?

Mr. **BIBBENS**. Two to one of the association of California members and those with joint membership with AEA, it was at least 50–50, a little over.

Mr. **MCDADE**. They responded in what, 10 days?

Mr. **BIBBENS**. That is correct.

Mr. **MCDADE**. There was also an argument, and the president of Stanford is quoted in every one of these articles, indicating the set-aside is a threat whether it be a 1-percent threat, the 3 percent this committee has reported out, is a threat to drying up basic research.

Let me quote from one of the comments apparently made. Then I would like you all to comment, particularly the other panelists who might wish to. He says that R. & D. devoted to basic research will be dried up, and small businesses simply aren't prepared to do the basic research now mostly performed at the big Government-owned labs.

Actually, and this is an article in the New York Times, potential loss is still greater. At the Stanford Linear Accelerator, much of the budget must be spent on equipment maintenance whether the machinery is used or not. So, a 1-percent cut in funding forces a much larger cut in research operations. The paragraph concludes, "The same is true for capital-intensive basic research in fields like biogenetics." Now, we have talked about the response of the national organization, not polling its membership, your organization doing it.

Would you address yourselves a little, please, to these comments that are being made? You have already indicated an association between the university and the association. Would you comment? How do you see this 1 percent, or 3 percent, whatever the figure might be? And you have said you don't really think it is important.

If you test the hypothesis, you will find it is going to work across the spectrum. But, I would like you to address the comments, because a lot of our colleagues are going to read the editorial and have read it, it is being circulated.

And I would like our record to reflect your opinion whether you do it individually. Suppose we start with you, Mr. Bibbens.

Mr. **Bibbens**. First of all, I believe that deals with an issue that Stanford has to address, not the U.S. Government R. & D. procuring activities. The focus of the R. & D. procurement activities should be how do we get the best research for the dollar?

Then it is Stanford's problem, if they have capital-intensive research programs, as to how they organize their structure to handle that. But I believe that their own data shows that even at the worst case, suppose it was mandated by law that it had to be a 1-percent reduction, and then that they had to reduce funds in the slack program by about 1 percent? That would not devastate it. It would reduce it by about 3 percent in their variable costs.

Their fixed to variable costs are about a factor of 3 to 1. So it is not going to devastate it. I believe all it is is a spurious argument that is aimed at protecting the already existing structure that has 100 percent of the money going to the universities in these areas.

Mr. **Larson**. Well, I can only support the views Mr. Bibbens just expressed. I think the issue should be what was brought up on the last panel, having to do with what is basic research.

We have no problem at all with universities doing the basic research. I don't think that is the intent of this bill. The idea is the innovation, the applying of the results of the basic research, the fruition of the research into a practical application, applied to well-defined national needs in a competitive way.

This is what we support in your bill. I feel there is a proper place for university research. I have certainly spent the bulk of my life in the Stanford Research Institute. One cannot really make a fair comparison between the academic community and small business community. They are both addressed to different problems.

I don't feel the 1-percent set-aside provisions of the legislation would really impinge at all on the academic community, although that has to be a biased view from where I stand right now.

Mr. **McDade**. No more biased, I would say, than the view in the editorial.

Ms. **Andrulis**. Let me comment to the term "threat." It is an interesting phrase. True competitors are not threatened. True competitors who are skilled and competent and qualified welcome the opportunity to be challenged.

So, I think it is an interesting juxtaposition with threatened, as you said, out of this editorial. I think it is also true that without the opportunity to demonstrate, you really don't know what the wealth of capabilities that exist are.

I make a point in passing. I think it is fascinating if a lot of the money are being put into the maintenance of existing equipment, maintenance and improvements, is that what you said? Did I hear you correctly?

Mr. **McDade**. Yes. Let me reread that for you. After saying there is going to be this tremendous loss, quoting Stanford, the second paragraph reads:

> Actually, the potential loss is still greater. At the Stanford Linear Accelerator, much of the budget must be spent on equipment maintenance, whether the machinery is used or not.
>
> So, a 1-percent cut in funding forces a much larger cut in research operations. The same is true for capital-intensive basic research in fields like biogenetics.

Ms. **Andrulis**. Well, just as a practical thought, the maintenance and usage of equipment doesn't have to be totally by the university. Small business could lease the use of equipment which are located on universities. As a matter of fact, we have done that for the past 6 years in a very cooperative way with a local university, and we have shared expenses with them.

Mr. **DiCicco**. I have spent, Mr. McDade, a lot of time going through each proposal ever submitted to the National Science Foundation SBIR program, and concentrated specifically on the issue of health care and the proposals that were submitted to them for research in that area.

Our clients last year funded 80 companies. We showed them the portfolios of Stanford, of MIT and all of the other large medical universities in the country. They were not impressed with it because of the tremendous amount of money it would take to commercialize a university research program as opposed to a small business program.

The research program at Collaborative Research, Orrie Friedman testified before, is much more superior than some of the things going on at Stanford. For the Small Business Committee, we have looked at the research programs that NIH funded over the last year.

We pointed out that there were research programs on cancer, specific markers that the medical journal said was a waste of time doing anything on.

The only companies nowadays that are going to tell you where that malignant tumor is in your body is a small company, not a university. They are simply not directing their research to commercialize something within the next 5 to 10 years.

Maybe off the record I might make a comment on one of the large medical companies. We presented them with two identical technologies. One from a small business, and the SBIR program, and one from Berkeley.

Their comment was that the technology from Berkeley was "berserkeley."

Mr. **McDade**. Thank you very much.

Mr. **Mitchell**. I, too, want to thank the members of the panel. Let me just set forth for the record that I think this Nation has taken a position that it is in opposition to cartels, or trusts, or monopolies.

And it appears that we are dealing with an academic monopoly. And that is totally inconsistent with what is the basic posture of this country. Thank you.

Mr. BIBBENS. Thank you very much.

Mr. McDADE. Mr. Chairman, let me say, before the next panel comes, that I regret that I have to leave. I have had a second committee meeting that began at 1:30 which I must attend, so I do not leave out of lack of interest.

We are glad you came. My minority counsel will be here to make sure that your testimony is all well taken. Thank you very much.

Mr. MITCHELL. Thank you.

Our next panel is our academic panel and consists of Mr. Sidney Green of Terra Tek, Inc.; Dr. William L. Walters, formerly vice chancellor and now professor of physics at the University of Wisconsin at Milwaukee; Dr. Fred Tarpley, professor of management, Georgia Tech, accompanied by Mr. Wayne Hodgins; and Mr. Harry D. Richardson, president of Nuclear Systems, Inc., in Baton Rouge.

It has been a long day and a long wait. All I can do is apologize and say we on the committee are very, very grateful. You have been here throughout the hearing. I think you have been impressed as much as I have by the testimony submitted.

I am sure yours will be of equal or superior value. Mr. Green, will you lead off for us, please?

PANEL CONSISTING OF SIDNEY J. GREEN, WILLIAM L. WALTERS, FRED A. TARPLEY, JR., AND HARRY D. RICHARDSON

TESTIMONY OF SIDNEY J. GREEN, PRESIDENT, TERRA TEK, INC., SALT LAKE CITY, UTAH

Mr. GREEN. Mr. Chairman, I am pleased to support the innovation bill. I hope the bill eventually will be passed and that an amendment will not dilute it to the point where it will be inoperative and ineffective. I have written statements both from myself and from Prof. Wayne Brown of the University of Utah that I would like to submit for the record.

Mr. MITCHELL. Both will be submitted in their entirety.

[The prepared statements of Mr. Green and Mr. Brown follow:]

PREPARED STATEMENT OF SIDNEY J. GREEN, PRESIDENT, TERRA TEK, INC., SALT LAKE CITY, UTAH

Mr. Chairman, honorable Senators and Congressmen, panel members and guests, I will present testimony to innovative and productivity and specifically on the topic of this hearing, "Startup, Growth and Survival of Small, New, High-Technology Firms."

As a matter of record, I am president of Terra Tek, a Utah-based, high-technology company. Our company and its subsidiaries and affiliates employ about 150 people, and provide services and products to industry and Government clients involved in energy and resource recovery and development, civil construction works, defense problem solutions, advanced manufacturing applications, and advanced plant and biological sciences. Of our five separate corporations and three separate divisions, two of the groups routinely perform Government contract work, while four of the group do no Government contract work. Hence, we have a spectrum of businesses that range from consulting research and development, to manufacture and sale of products, to Government contract cost reimbursable-type work.

We began our organization in 1970, and last year our companies created 30 new jobs; we expect to add 40 to 50 new jobs in the next 12 months. We are currently developing about a dozen innovative, new products and services, many of which we expect to eventually bring to the marketplace. Also as way of background, I have advanced degrees in mechanical engineering, and prior to joining Terra Tek, I worked for a very large U.S. corporation.

When I address the general area of innovation and productivity and specifically the startup, growth, and survival of small, new high-technology firms, I am talking about the much studied topic of "industrial innovation." That is the process of moving new and different ideas for products, services, or processes, to commercial reality.

Industrial innovation is a process involving a number of phases. The startup or beginning, however, is when an inventor-entrepreneur promotes an idea with the intent of eventually bringing the idea into application commercially. In our free-enterprise system this means the integration of the new idea into a company or venture structure of some kind, and then promoting the idea aggressively. At a later time, after the idea has been demonstrated at least to some extent to be commercially viable, growth and expansion of the business occurs as the product is expanded into the marketplace. Each of these phases has different requirements, but all of them require significant risk taking, and history has shown that all of them require a strong entrepreneurial spirit of the individuals involved to successfully move the idea along. The whole process is industrial innovation, the application of high-technology ideas.

In the process of industrial innovation, the universities, the national laboratories, the not-for-profit research institutions, big businesses and small businesses all contribute inventor-entrepreneurs to the process. Numerous studies have shown, however, that the small high-technology firm—frequently a firm with a few to a few tens of people—offers the best environment for the entrepreneur to be innovative. Innovation is clearly a process where big is not better; and, in fact, well-documented investigations show that high-technology firms produce a very, very disproportionately large share of industrial innovations; of the order of one half or more. Yet at the same time, small businesses have access to relatively little capital, relatively small amounts of equipment and facilities, and relatively little in the way of management know-how skills required to compete with big institutions and big bureaucracies. Small businesses are simply frequently not in the same league as the big institutional bureaucracies when it comes to having the know-how to deal with tax and legal problems, Federal and local government regulations, and competing in a marketplace primarily by big competitors.

It is particularly worthy of note that even with these extreme handicaps—lack of financial resources, lack of equipment and facilities, lack of ability to handle big institutional problems—yet the small, high-technology firm still produces a very, very disproportionately large amount of industrial innovations.

I should note at this stage that of the 12 million or more small businesses in the United States, small high-technology firms constitute only maybe 20 to 50,000 of the small businesses. This makes it even more noteworthy that such a small number of business with access to such a small amount of capital, facilities, and the like are contributing a large number of industrial innovations.

Many groups including this current Government hearing are trying to determine what will assist the acceleration of industrial innovation. It is most appropriate that the Senate and House Small Business Committee should address this problem, for as noted above, the small high-technology firm plays such a significant role.

Experts from all parts of the U.S. free-enterprise have met on numerous occasions, just as this hearing is meeting, to provide the background information in the form of solid facts as to what will assist industrial innovations. For example, the recent Small Business Administration Office of Advocacy, "Task Force Report on Small Busines and Innovation" is one such well documented investigation. The Federal Government can do things that significant favorably affect high-technology firms; and, therefore, allow the small, high-technology firm to accelerate the innovation process.

It is very worthy to note that in the well documented previous investigations, there is unanimous agreement that industrial innovation is something that must be accomplished in the private sector, free-enterprise system. The free-enterprise system with its reward for risk-taking in the form of capital accumulation, simply cannot be accomplished very well in Government laboratories, universities, or not-for-profit institutions. This is not to say that these groups will not pay an indirect role in industrial innovation, but industrial innovation itself by unanimous agreement is a private-sector, free-enterprise activity.

As stated earlier, the different phases of industrial innovation, including the early inventor-entrepreneur activities, the establishment of a company or venture structure, and the expansion and growth stages, could well be aligned with the title of this hearing: the startup phase, the survival and expansion phase, and finally the growth phase to a larger maybe different structural entity. Since these phases involve different activities and even maybe different participants, it is not surprising that the requirements in each phase are different. Nor, that Federal Government activities to assist would receive different priorities for the different phases.

For example, in the startup phase, the inventor-entrepreneur is probably not worrying very much about Government regulations. There is instead more concern about getting enough money to literally put bread on the table and pay the bills. In this phase the entrepreneur is beginning to think about patents and a proprietary position. In the second phase, the entrepreneur is concerned with survival and expansion into a commercial market. Here the entrepreneur is very concerned about obtaining enough resources for continued development. Tax burdens, methods of obtaining other support via favorable equity sale, patents and the establishment of a strong proprietary position are also of concern. In the third phase the entrepreneur is greatly concerned about raising large amounts of capital, building the management systems necessary, and Government regulations and taxes will also be high priority concerns.

Obviously as one polls high-technology businessmen, different emphasis will be placed on priorities, depending on which "phase" the entrepreneur is in. Even though the priorities that are given are different from entrepreneur to entrepreneur, there is unanimous agreement as to what is needed for each of the different "phases" of industrial innovation. The documented data all agree on priorities for a given phase.

I have considerable personal experience at industrial innovation in the first phase—the new startup phase—particularly the very, very early stage where even commercial feasibility of a new idea has not yet been demonstrated. This early stage is generally before venture capital groups will become involved; and, of course, it is before a public offering to raise capital is feasible. In this phase the entrepreneur invariably spends much of his time obtaining resources to pursue his idea, as opposed to actually pursuing the idea.

I feel that Government research and development (R. & D.) procurements play a very significant role in this early stage. These funds will frequently provide the entrepreneur with the resources to keep bread on the table and pay the bills. It is common for the entrepreneur to work on Government R&D contract in the general area related to the idea being promoted. In fact, I frequently recommend to the inventor-entrepreneur that he use Government R&D funds to finance the high-risk development costs while commercial feasibility is being shown. The entrepreneur, who is extending himself by working long hours and aggressively accepting high-risk tasks, is able to perform the requirements of the Government R&D contract, and at the same time continue to promote the new idea. There is therefore a double benefit from the given Government R&D contract.

It is clear to me, therefore, that if Government R&D procurement policies can be made less burdensome to the small, high-technology firm, that everyone will benefit. For example, a decade ago, it was common practice to discuss an "idea" with a Government Mission Agency, and to receive an R&D contract to do research on this idea after the submission of an Unsolicited Proposal. There was much more latitude for such open discussions at the Program Manager level, and much more freedom for the Agency to make decisions which would lead to contract award from such an Unsolicited Proposal arrangement. Today it is almost impossible to have an "idea" even considered informally by the Agency; and the Government Mission Agencies simply do not generally fund work from an unsolicited proposal (except for the National Science Foundation, which is not a Mission Agency). Admittedly the intent of using lengthy solicitation notices and doing away with Unsolicited Proposals is to avoid the handout of taxpayers' money on a "Good Charlie" basis. Unfortunately this action has had adverse side effects, that are costing the taxpayer much, in my opinion.

A second problem in Government R&D procurement policies is the rush by the large National Laboratores (such as Lawrence Livermore Laboratory, Sandia, Los Alamos National Laboratory, etc.) to secure reimbursable funds for their people to work in any area where a Federal Government agency has R&D funds. These laboratories are frequently competitors with the small, high-technology firm. Congressional and Administrative actions of the past decade have made it easy, desirable at times, and even required at times for the Mission Agencies to use National Laboratories. A transfer of funds from one Agency to a National Laboratory can be accomplished much easier than the funding of an outside private-sector contractor. The intent no doubt has been to use the pool of engineering and scientific talent and facilities that are assembled at the large National Laboratories. This has the very adverse side effect, of causing the Federal Government to fund "Government" people to compete with the private-sector scientists and engineers. The net effect has been to remove Government R&D money from the inventor-entrepreneur in small high-technology firms.

These two examples are but two Government R&D procurement policies that adversely affect industrial innovation. Changes needed have been presented before, including in the Small Business Administration report mentioned previously.

A particularly noteworthy Government program being conducted as an experiment by the National Science Foundation, is their Small Business Innovation Research Awards program. This Program is specifically designated to fund the inventor-entrepreneur to perform applied research which would have a long-term benefit to the nation. (Supporting research is the primary function of the National Science Foundation.) And, at the same time which would have a high probability of leading to industrial innovation. This program therefore bases contract awards on both the quality and nature of the applied research to be performed, and on the probability of success for the industrial innovation. It is a very interesting concept, and one that I believe will allow a large return for taxpayer dollars.

In summary, for the first phase of industrial innovation—the very, very early startup—the inventor-entrepreneur is struggling to gain resources to promote his idea. I argue that here Government R&D procurements play a very significant role. Obviously not every inventor-entrepreneur will find Government R&D contracts in his game plan; but for many inventor-entrepreneurs the Government programs will play a major role. Even a small percentage increase in Federal Government R&D procurements going to small high-technology firms (for example, raising the percent of R&D procurements secured by small businesses slightly above the current approximately 3½ percent level) will have a profound effect in terms of the large amount of dollars that could be made available for the inventor-entrepreneurs.

I am pleased that the Senate and House Committees have placed priority on determining Government actions that may assist industrial innovation. The very nature of these hearings—that is the Senate and House Small Business Committees—indicates an appreciation for the important role that small businesses play. I believe that it cannot be stated too strongly that what is needed is action that will support the creation and development of high-technology small firms involved in high-technology businesses. Such support will accelerate industrial innovations.

PREPARED STATEMENT OF WAYNE S. BROWN, PROFESSOR OF MECHANICAL ENGINEERING, AND DIRECTOR, UTAH INNOVATION CENTER, UNIVERSITY OF UTAH

The spin-off of technology-related businesses from America's universities has had a profound impact on the American economy. The roots of much of the high-technology industrial development of California's Silicon Valley and Boston's Route 128 can be traced to outstanding universities, which through various ways encouraged the formation and growth of technology-based companies. Engineering schools have a long history of fostering industry-education interaction, and they are an integral part of the infrastructure necessary for a successful technology-based economy. Their resources are particularly valuable to start-up companies that can utilize faculty members as consultants and gain access to expensive instrumentation and computers to assist their technical efforts. Since all universities receive considerable public support, it is indeed appropriate that their resources be made available to small technically-based companies which have demonstrated such a superior record for producing technical innovations and creating jobs.

Anything that universities can do to improve the economic climate is, of course, in their own best interests. Increases in productivity and jobs result in a greater tax base which makes possible more Federal R&D funding as well as direct support to state institutions. Thus, encouraging technical spin-offs from universities and making their facilities and staff available to small companies can have long-term beneficial effects. The University of Utah Research Park adjacent to the campus has provided incubator space for several fledgling companies which have since grown into successful businesses employing hundreds of people in desirable, good-paying jobs. Research Park is becoming the focal point of a growing high-technology complex in Salt Lake City.

The legislation under consideration which would shift a small fraction of Federal R&D expenditures to small business can have a strong impact on our country's economic viability. From first-hand experience with several small companies, which have received grants from the pilot program run by the National Science Foundation, I am convinced that the $30,000 grant was essential to getting the project started. As an example, the Utah Innovation Center encouraged a small company consisting of two capable, dedicated Ph.D.'s to apply for an NSF grant. The grant funds enabled this struggling young company to run a crucial experiment which demonstrated the validity of a new separation process with broad commercial potential.

Funds are now being sought from private investors to continue the project, and due to the success of the initial work, the prospects are excellent.

Expansion of the NSF pilot program to the broad R&D base of all Federal agencies will have significant payoff for Americans. The dedicated and committed technical personnel in small companies perform high quality research, and the potential for economic rewards which exists so clearly in small companies is often the key to converting the research results into successful innovative products and services.

It is my opinion that the universities should welcome Federal programs of the type under consideration and encourage cooperative arrangements with the companies which receive the grants, thus further strengthening the academic-industry bridges.

Mr. **GREEN**. For the record, I am president of Terra Tek, Inc., a high-technology family of companies located in Salt Lake City. We have considerable experience at high-technology companies' startups.

We have now developed, and nurtured eight different entities. I am also adjunct professor of mechanical engineering at the University of Utah and, hence, have a close tie with a major university.

Additionally, Terra Tek has affiliations with a number of the major universities including Brown, Stanford, Cal Tech, U.C. Berkeley, MIT and others via an active consultant relationship.

We have consultants at these universities, minor stockholders of our companies. They are individuals active with our company, in some cases, all during our company's life.

First, I would make a brief comment on my written testimony. In the first phase of high-technology startups, the very, very early startup stage the inventor-entrepreneur is struggling to get resources to promote his idea.

I argue that there in this phase the Government R. & D. procurements play a very significant role. Obviously not every inventor-entrepreneur will find Government R. & D. contracts in his game plan, but for many of the inventor-entrepreneurs, the Government programs will play a very major role.

Even a small percentage increase in Federal Government R. & D. procurements that would go to small high-technology firms would have a very profound effect in terms of giving a relatively large amount of added dollars to the inventors and entrepreneurs.

This, in turn, will, I believe, unquestionably help the startup of many new businesses.

Second, I would like to present part of a written statement by Prof. Wayne Brown, who is professor of mechanical engineering at the University of Utah.

Dr. Brown is deeply sorry that he could not be here in person, but he has asked me to present his statement.

Dr. Brown is not only professor of mechnical engineering, but he is a former dean of engineering with the University of Utah, and is director of the University of Utah's Utah Innovation Center.

I quote directly from one paragraph from his statement:

> Anything that universities can do to improve the economic climate is, of course, in their own best interests. Increases in productivity and jobs result in greater tax base, which makes possible more Federal R. & D. funding as well as direct support for State institutions, thus encouraging technical spinoffs from universities, and making their facilities and staff available to small companies can have long-term beneficial efforts. "The park adjacent to the campus has provided incubator space for several fledgling companies which have since grown to successful businesses providing desirable good-paying jobs. The legislation under consideration would shift a

small fraction of Federal R. & D. expenditures to small business can have a strong impact on our country's economic viability.

That concludes my quote from Dr. Brown's statement.

In conclusion, I don't believe very many people, maybe not anyone, is arguing against the results that would come from a small business innovation development bill. The question has to do with the mechanics of how the Federal Government should proceed.

Arguments against the bill generally seem weak to me and, in some cases, lack understanding. What I see at times is a lack of understanding of high-technology startup. There is talk of lack of venture capital being available, but no lack of dollars to start up a company.

There indeed are not dollars available for early, early startup. As other witnesses have indicated and I concur with them, obtaining funds for the early, early stage to coalesce the idea, develop the manager, start the venture, obtain those kinds of dollars, is very difficult.

This bill would provide, at least help to provide funding for this early stage. I agree with the former witness that, if compromise is needed, I strongly urge that we keep the mandatory provision requiring all agencies and all programs be included, that is, not excluding basic research.

Second, then, if we need to, lower the percent minimum requirements. Finally, Mr. Chairman, our company believes this kind of a program works. And so, we have put our money where our mouth is, if you will.

We have created an in-house program where we give such grants to our own employees. We give out up to $10,000 grants to our employees to try to develop new products and services.

We have given 11 such grants in the last 3 years. I am pleased to say two of those grants have now led to new companies, spinoff ventures from our company. So, if you will, we put our money where our mouth is. We believe it works not only for the Federal Government but for in-house purposes.

I thank you for being able to make these comments.

Mr. MITCHELL. Thank you. Thank you very much.

Mr. Tarpley.

TESTIMONY OF FRED A. TARPLEY, JR., PROFESSOR OF MANAGEMENT, GEORGIA TECH

Mr. TARPLEY. Mr. Chairman, it is a pleasure to have the opportunity to offer testimony before this committee in support of the Small Business Innovation Development Act.

My name is Fred A. Tarpley, Jr., and I am a professor in the College of Management and a staff member of the Advanced Technology Development Center of the Georgia Institute of Technology, a new entity aimed at assisting innovative technology in the State of Georgia.

For several years, I have had an opportunity to view the operation of the National Science Foundation's small business innovation research program, upon which this legislation is based, from a number of perspectives: First, as a professor concerned with questions of innovation and productivity; second, as a program associate with NSF's industrial program during the early days of the small business innovation research program; later, as director of the office of economic research at SBA and principal economist of the national productivity group of the General Accounting Office; and, finally, as a staff member of a State program aimed at encouraging the development and growth of high-technology businesses.

By the early 1970's, it was becoming increasingly evident that the rate of technological innovation within our economy was less than that which would be needed to maintain full employment and continue our rate of economic growth.

Among the problem areas that were identified were increasing the rate of commercialization of federally funded research and development and developing an environment which maximized the capabilities of small technology-based companies to contribute to the innovativeness of the economy. The small business innovation research program was developed by NSF to address these twin concerns. The SBIR program was designed to answer the question of whether small technology-based firms could participate in federally funded, research-supported programs in topic areas of national concern.

An abbreviated proposal process and certain modifications of patent procedures were made to increase the attractiveness of the program. The collaboration of small business firms with university-based researchers and the inclusion of agreements on the part of venture capitalists or other third party financial sources were treated as points of merit.

As has been testified to here today, the SBIR program has been a major success. This has been accomplished with minimal, if any, addition to staff. Quality research has been conducted by small business in areas in which NSF would have been conducting research even without this program. Many of the program managers at NSF from some of the more basic disciplines have changed in a relatively short period of time from being severe critics to being ardent supporters.

The emphasis on securing third party financial commitments has hastened the commercialization of the projects which have been supported under this program. In addition, NSF has received a large number of quality proposals from small business firms and has widened the participation in its research programs.

The fact that less than 1 out of every 10 of the proposals submitted has received funding in the first phase, and only half of those in the second phase, and still the program maintains popularity within the small business technology community, should lay to rest any concern that this is not a competitive program. The normal figures for NSF, or somewhere between 45 and 50 percent of the proposals submitted are funded. And in many of the programs of NSF, the percentage approaches 100 percent as a limit.

In my stay at SBA and later at the General Accounting Office, I worked closely with both the high technology R. & D.-intensive small business community and with venture capitalists. I found in both of these groups a tremendous excitement for and support of the Small Business Innovation Research program and as well as attempts to extend it to other areas. Small businesspersons were appreciative of the fact that the SBIR program attempts to include them in the nation's research and development efforts. They are also appreciative of the critical support during the phase of determining scientific and technological feasibility.

This preventure period is often the most difficult period in terms of securing financial resources, even though the absolute need for resources may be relatively small. The venture capital community sees this program as helping them identify new firms with emerging technologies that have survived a very tough screening process and, thanks in part to the SBIR phase I and phase II support, should be on the road towards commercialization. The fact that few, if any, new federal research dollars are needed to implement this program appeals to the basic nature of small businesspersons and venture capitalists alike, who are notorious for trying to make one dollar do the work of three or four.

Presently, as I mentioned, I am staff member of the Advanced Technology Development Center (ATDC) of Georgia Tech. The ATDC was set up by the State of Georgia in response to a perceived need. That need is that many of the major industries upon which the State depends for much of its employment, areas such as textiles, apparel, and food processing, are low-wage, low-value-added industries and are subject to extensive competitive pressures from abroad.

The ATDC was established to serve as a focal point for the development of high-technology industry and employment for the State. If Georgia is to maintain its economic progress, it must develop high-value-added, high-wage employment in industries which will be expanding in the 1980's and 1990's.

For many years Georgia has competed with its sister States for large manufacturing and assembly operations of established firms in mature or maturing industries. Recent economic performance brings into question both the attractiveness and effectiveness of relying solely on this strategy. Cutthroat competition to see who can give the most concessions to industries locating their facilities within a State is expensive and is essentially a zero-sum game. What one State wins, some other State loses, and vice versa.

Georgia, with its commitment to the ATDC and the recent support it has given to its vocational-technical education system, has decided to follow a balanced developmental strategy. The emergence of the semiconductor industry in Santa Clara County, Calif., and of the microelectronics industry around Route 128 in Massachusetts illustrates how the development of new technologies and applications can create rapid increases in employment and the local tax base.

Innovate small businesses played a major role in both of these developments. Resulting jobs tend to be high-value-added, high-wage jobs in growing, nonpolluting industries, the kind of development Georgia, and, indeed any State, wants.

Georgia intends to develop a strong and vital high technology small business community. Georgia Tech, as its dominant engineering and science facility, will serve as a catalyst for this development.

The ATDAC at Georgia Tech offers high technology small businesses incubator space on campus, technical and management support, and access to Georgia Tech personnel and resources. We are hopeful that our nascent small high technology business community can grow and prosper. The success of this effort can be measured by the number of jobs created at favorable wage rates, including, hopefully, job opportunities for Georgia Tech graduates.

The success of Georgia in "growing its own" high-technology firms and employment should not adversely affect her sister States. Economic development of this type is a positive-sum game.

Approximately one-half the winners during the SBIR solicitations have come from five States. Unfortunately, Georgia is a long way from joining this group. But the expansion of access provided small technology-based firms to Government supported research is important for States like Georgia and to institutions like Georgia Tech.

In a State with only a limited tradition of technological entrepreneurship, the opportunity to compete for research support in the full range of Government research programs will provide great encouragement to emerging small high-technology firms. In the process of proposal preparation, contracts will be developed with both university-based researchers and existing small technology firms both within and outside the area. Networking will occur, and, hopefully, we will begin to develop what already exists in places like California and Massachusetts, a high-technology infrastructure.

The expansion of access to Government R. & D. support as contained in this act, can be of benefit to universities like Georgia Tech. The encouragement of small, high-technology firms to participate broadly in Government R. & D. efforts would create opportunities for creative interaction for both students and staff alike, as well as possible employment opportunities for graduates.

One of the things we hate to see in Georgia is that we graduate a large number of engineers who cannot find jobs in Georgia. The development of successful technological entrepreneurs, which this act would encourage, would provide role models for students and even faculty who want to participate in that most American experience, going into business for oneself.

Mr. Chairman, I fully endorse the passage of the Small Business Innovation Development Act. This act is peculiarly appropriate for this time in our history. It requires little, if any, additional expenditures. It encourages increased competition by qualified scientists and engineers in Government research programs. It will harness one of the most creative components of the American society, small business, to help develop solutions to the country's problems.

Quite frankly, it will help States without a high-technology tradition, such as Georgia. But, more importantly, it will help the country.

This ends my testimony. Thank you.

Mr. **Mitchell**. Thank you very much.

Mr. Walters.

TESTIMONY OF WILLIAM L. WALTERS, PROFESSOR OF PHYSICS, AND FORMER VICE CHANCELLOR, UNIVERSITY OF WISCONSIN AT MILWAUKEE

Mr. **Walters**. Probably the most important thing I could do here today would be to illustrate for you that the higher education community is not monolithic on the matter of SBIR. What you have heard from is the establishment, or portions of the establishment, of high education. There are those of us who would take an opposite point of view. And apparently we have been too reluctant to come forward.

I have spent 15 years in administration in higher education. I am a physicist by native trade, but in that time I have learned quite a bit. A lot of it has been at the awesome experience of seeing high-quality individuals and truly bright people produce.

Another thing I have learned is to be brief. So I am going to highlight the written statement that I have left with you for the record and be as brief as I can.

The bill you are considering is intended to help small businesses couple to scientific research and development activities, to draw from these activities new product development and capital investment, and to contribute to these R. & D. activities their own human and financial resources. It seems to me that one result of H.R. 4326 could be healthy for universities as well as small businesses.

American university scholars can take pride in being on the cutting-edge of discovery and innovation. Furthermore, there is a great tradition of openness—publication, conference and symposium discussion, and enlightened mutual testing of hypotheses and findings by the specialists in any given field. As a result there is much valuable information in the public realm and each element is openly and honestly identified with the person(s) with a commanding knowledge of it. I am convinced that a well-conceived SBIR proposal written in accordance with the provisions of H.R. 4326 will identify these very same people as critical resources. It follows that there could be propitious involvement of the university principals and their students in the early stages of the SBIR project. There are many benefits that accrue to universities from such involvements.

For one thing, I believe that the SBIR program would widen the constituency of American science and technology. There is profound concern about recent survey results, Science Indicators, which indicate that public support for science and technology is waning. It is difficult—probably impossible—for the general public, or even those more knowledgeable about science in general, to extract the significance from a meeting of the Optical Society of America or the Institute of Electrical and Electronic Engineers.

However, if some of these same concepts were brought into the more grassroots setting of a small business—as part of an SBIR project—it would contribute to a broader appreciation for academic science. At the very least there should be a heightened respect for the importance of scholarly publications and the human resource behind them.

That is a self-serving statement on behalf of the university, but I believe it is true.

Finally, my years as a university administrator have taught me to look at new initiatives such as the SBIR program in an objective, analytical way. I find two elements of it that are especially noteworthy: (1) The grants are to be competitive, not a formula-driven dole, and (2) there is a reasonable startup period.

I comment in a couple of paragraphs about why those are important elements, but I would not dwell on that here. I am here to support the basic intent of the Small Business Innovation Development Act. I think it has social and scientific merit. It should be good for small business and could have a salutary effect for the academic scientific community.

[Mr. Walters' prepared statement follows:]

PREPARED STATEMENT OF WILLIAM L. WALTERS, PROFESSOR OF PHYSICS, AND FORMER VICE CHANCELLOR, UNIVERSITY OF WISCONIN AT MILWAUKEE

The objectives of the Small Business Innovative Development Act are lauditory and should be supported by persons attentive to the ongoing relationships between technology and business. Certainly there are areas of overlapping, common interest between developing areas of technology and the growth strategies of a wide variety of businesses. One need only to look at the recent history of mankind to recognize that phenomenal advances in personal productivity and standards of living have been wrought from technical innovation. This country has been a leader in these advancements. It is proper that we build on this strength in the future.

The bill you are considering is intended to help small businesses coupled to scientific research and development activities, to draw from these activities new product development and capital investment, and to contribute to these R. and D. activities their own human and financial resources. Federal funding would come from the existing R. and D. budgets of the larger federal agencies. And that has elicited criticism from some universities and groups that have an overarching interest in extramurally spent federal R. and D. funds. It seems to me that the result of H.R. 4326 could be healthy for universities as well as small business.

American university scholars can take pride in being on the cutting-edge of discovery and innovation. Furthermore, there is a great tradition of openness—publication, conference and symposium discussion, and enlightened mutual testing of hypotheses and findings by the specialists in any given field. As a result there is much valuable information in the public realm and each is openly and honestly identified with the person(s) with a commanding knowledge of it. I am convinced that a well-conceived SBIR proposal written in accordance with the provisions of H.R. 4326 will identify these very same people as critical resources. It follows that there could be propitious involvement of the university principals and their students in the early stages of the SBIR project. There are many benefits that accrue to universities from such involvements.

We can learn from each other. A good university professor must maintain an up to date knowledge of what is going on in his or her field of specialization. Seldom is there a meeting attended or a professional communication that does not stimulate new ideas or introduced new state-of-the-art techniques. These things have relevance in the classroom and for in-house research. The same would be true when there is university interaction with SBIR projects. It would add to the university environment techniques, anecdotes, and from-the-field knowledge that could add up to the perspective students and faculty give to the work they are currently doing.

Secondly, I believe that the SBIR program would widen the constituency of American science and technology. These are difficult times for universities. Budgets are being cut and student enrollment patterns are changing at rates that are exceedingly difficult to accommodate. Faculty morale is sagging, even among the scientists and engineers—fields which tend to be the most vigorous at the university. This has lead to a certain amount of breast-beating and self doubt about public support for higher education. There is profound concern about recent survey results which indicate that public support for science and technology is waning. It is difficult—probably impossible—for the general public, or even those more knowledgeable about science in general, to extract the significance from a meeting of the Optical Society of America or the Institute of Electrical and Electronics Engineers. However, if some of these same concepts were brought into the more grassroots setting of a small business (as part of an SBIR project) it would contribute to a broader appreciation for academic science. At the very least there should be a heightened respect for the importance of scholarly publications and the human resource behind them.

My years as a university administrator have taught me to look at new initiatives such as the SBIR program in an objective, analytical way. I find two elements of it that are especially noteworthy: (1) The grants are to be competitive, not a formula-driven dole, and (2) there is a reasonable start-up period.

Outside peer review of proposals is, in my judgment, absolutely essential. One always hopes that the feedback loops in a new "product" is such that there will be an improvement as time goes on. The use of peer review panels should have that effect on the SBIR program. Not only would this practice provide the necessary quality control but it would also nourish respect for SBIR among the reviewers. I think some of the critics of the SBIR initiatives in Congress have too low of an opinion concerning the quality of what will emerge. Perhaps they have forgotten that peer review is a well-tested concept in higher education, that it represents a critical test of the scientific and technical merit of a given idea. I find it reassuring that both H.R. 4326 and the corresponding Senate bill (S. 881) require outside peer review.

There is a four year phase-in period in the bill that has been drafted. It is prudent to provide for a start-up cycle such as this. Too often in the past instant starts were assumed. They prove not to be practical. As one who has had to deal with budget and program discontinuities I am of the opinion that, though they attract attention, they are wasteful. It requires time to stimulate the intellectual energy it takes for the best people to exploit a new target of opportunity. And it requires time to orchestrate changes in budgets. The people at the federal agencies that would have to start SBIR programs most likely need three or four years to establish new communication links with small business and to shift their budget allocations.

Some would characterize the SBIR initiative as a basic research vs. applied research issue. I cannot agree with such a generalization. Such arguments try to draw a contrast where none exists. Any reasonably comprehensive program of basic experimental research will encounter problems of a pragmatic, applied nature. Though the central thrust might be the advancement of basic knowledge, progress often requires concomitant solutions to applied problems—measurement techniques, signal to noise ratios, microprocessor coupling, etc. On occasion it is these latter solutions, the spin-offs, that become important innovations in their own right. There is a synergistic relationship between basic and applied research that has innate value. I see SBIR projects as a logical extension of that relationship, an extension into the private sector.

The requirement that the SBIR programs be established from the existing budgets of the federal agencies carries with it some operational difficulties. But are these difficulties insurmountable? Again, using my experience as a former university administrator, I conclude that they are not. The three to four year phase-in period and the relatively modest percent effort that is envisioned (3 percent in H.R. 4326; 1 percent in S. 881) means that the annual rate of change in any given agency budget would be a fraction of a percent. The fact that this comes on top of losses of several percent per year due to inflation compounds the management problem. Nevertheless, the functional crossover of funds for SBIR does not represent a discontinuity, but rather a longer range plan for redirection of resources. I see no spectre to worry about with respect to budget.

In summary, I am here to support the basic intent of the Small Business Innovation Development Act. I think it has social and scientific merit. It should be good for small business and it could have a salutory effect for the academic scientific community.

Mr. Mitchell. Thank you, sir.

Mr. Richardson.

TESTIMONY OF HARRY D. RICHARDSON, CHIEF EXECUTIVE OFFICER, NUCLEAR SYSTEMS, INC., BATON ROUGE, LA.

Mr. Richardson. Mr. Chairman, thank you for the opportunity to be here and present these comments. I have prepared comments, and they are rather lengthy. So rather than go through those I think I will just try to summarize those and speak to some of the comments that have been expressed.

Mr. Mitchell. Fine. Your entire statement will be in the record.

Mr. Richardson. Thank you.

I was asked to speak somewhat to the argument that small business cannot do innovation. I did not know I was going right to that point, that point that you were going to open the meeting.

My background is academic as well as innovation technology companies. I am not sure when I started back in the 1950's that I had the idea of building a company. My background is in mechanical electrical engineering and I spent about 20 years on several different engineering faculties.

But in those days faculty members had a lot of spare time and I was looking for something to do on weekends and holidays, so as a result of work there were product ideas that developed.

The first work we did was in the 1950's and we were trying to find applications of radio isotopes which had only recently been declassified and available for nonmilitary purposes. As a result of that we had developed products now used in a couple of countries scattered around the world, and this still remains to be the largest, strongest most viable part of our company.

I will come back to nuclear products a little later. In 1976 we decided we needed to find something that had a little more rapid growth, so we began to look at energy conservation, and energy management company opportunities. Of course, there are many big companies developing computer and control systems for big buildings. Our approach was to take the attitude that waste not, want not, and look at little buildings, single family dwellings, small commercial industrial type buildings.

The first product we put on the market has been there a little over 2 years, and so far we have sold about 35,000 of these devices. If we can believe the testamentary letters from some of our customers, they indicate they have saved about $30 million on their utility bills. When you go further and look at their 93 million or more metering points within the United States, that suggests there can be a significant savings in utility bills by looking at simply the conservation and the management of electrical energy in the small users, as well as the big ones.

We had another product that is just now getting ready for the market. We have had large utilities that have given us some of their engineering talents. They say this will reduce their peak loading by approximately 9 percent. Well, this will delay the capital required for investment in new distribution and new generating facilities.

You can reduce the peak load on a utility by 9 percent. We feel this is significant. This also is for single family dwellings, small commercial, small industrial buildings. The opportunities here seem to be almost unlimited if somebody were to look at it. The difficulty of course from a small business viewpoint is how do you get out to the 93 million potential metering points to let them know about it, because a little company just does not have access to the resources for the dissemination of information.

We cannot release the name of it, but we got a notice last week from one of the public utilities. This is after more than 2 years of testing and working with them, that they will give a $50 rebate to each one of their customers which installs this device, plus will give them 10-percent financing on the installation costs.

Mr. **Mitchell**. Can you not give the name?

Mr. **Richardson**. I will be happy to give the name as soon as I feel as though they have definitely confirmed this. You can be sure we are excited about that, because, if it is successful with them, it should have a domino effect.

Well, the last one that I had in the prepared materials was to refer to nuclear items, that they call wastes. It is my opinion that eventually these will be recognized not as waste but as national resources. Work done at LSU as well as five other universities about 20 years ago, cannot be utilized in the United States today, but there are foreign countries that are effectively commercially using nuclear waste to irradiate food. Among the countries which permit food irradiation are Israel, Canada, Hungary, United Kingdom, Germany, and France.

And it completely escapes me why we are swayed from using this information; it is already existing knowledge, to be applicable to existing problems or opportunities here in the United States.

Foreign countries do pick them up. If I may I would like to refer to one of Mr. McCloskey's statements. He said he would like to have some examples of small versus big and why small has a problem. On one Government project, the MX missile program, we were evaluated and told we had all the competence to do the job. But we would not be considered because they would rather work with larger companies.

A second example, a good many years ago, some 7 or 8 years ago, we had developed instruments for use in nuclear medical laboratories and these were selling very well. We were immediately destroyed in the market because three of the very large companies went to the hospitals and said, we will give you the instrument at no cost provided you buy the pharmaceutical material from us. Well, we are not large enough to give away $10,000 instruments.

So again, small versus big is real, and I do not know what can be done if anything to try to change this. Anybody that does not recognize that small versus big is a real problem should come sit in the chair of the administrator of a small company and he will find out that it is real and it is there every day.

For whatever my comments might be worth, I think that small businesses are very much interested in this legislation. I have been involved at the university level, and I spent a good portion of my time as an administrator seeking funds. And I might say that I successfully brought in quite a bit of money to many university departments.

So I have been involved in that area. We must have university work simply because one of the functions of a university is to seek and record additional knowledge, and then use that process in the education of students, particularly graduate students.

The second phase of this, which has been alluded to so many times, is simply that once the academic research is done, it is recorded. But that does not at all provide the interest for venture capital. So the second phase is that someone must do the additional work to put the basic work in the form that will be attractive to the venture capitalists.

The third form, of course, is the kind of company that I am involved in now, where we try to bring the technology products into the marketplace. Having been involved on both the academic and the industrial side, I think I see all three viewpoints. I think there is need for all three of them. And I personally fail to find any conflict that any faculty member that wanted to apply for this kind of funding would be restrained from doing so.

Thank you, sir.

[Mr. Richardson's prepared statement and attachments follow:]

PREPARED STATEMENT OF HARRY D. RICHARDSON, CHIEF EXECUTIVE OFFICER, NUCLEAR SYSTEMS, INC., BATON ROUGE, LA.

INTRODUCTION

Nuclear Systems, Inc. is a small public company. Its headquarters is in Baton Rouge, Louisiana. Its manufacturing facilities are located in Baton Rouge, La., Jefferson City, Tenn., Houston, Texas, and Acuna, Mexico. It has served customers in all parts of the United States and more than 25 foreign countries since the early 1950's.

NSI was created to be an innovative high technology entity. Applications of nuclear energy provided the initial thrust and this continues to be the major company segment. Recently, NSI has based expansion possibilities upon developing products which are concerned with energy conservation and energy management.

Many companies have developed heating and air conditioning control systems for large buildings. NSI has addressed efforts to conserving electrical energy consumed in small buildings. This includes single family dwellings and commercial/industrial buildings.

INNOVATIVE ENERGY CONSERVATION

Worldwide problems of energy availability and cost have been postulated and thoroughly documented. An old saw, "waste-not-want-not," provides sufficient wisdom for defining a major attack on reducing the amount of electrical energy consumed in small buildings. A waste-not-want-not attack provides decreased utility bills and also reduces the depletion of oil, gas, and coal required to generate wasted electricity. Small inexpensive devices are required. Three different efforts are apparent: (a) energy conservation; (b) energy management, and (c) energy monitoring.

Products for accomplishing these energy conservation goals are developed upon the leading edge of electronic technology which includes microcomputers, microprocessors, integrated circuits, et al. No additional basic research is needed. This is innovation technology at its best: applying existing knowledge to solve existing problems.

A. ENERGY CONSERVATION

NSI's first energy conservation product, the SMARTSTAT, was introduced 2 years ago. More than 35,000 have been sold. Each installation costs between $350 and $600, depending upon local conditions. Consumers report electricity savings from 15 percent to 40 percent with average savings in the mid-20 percent range. Selected consumers report total return of investment in less than 6 months and others range to approximately 18 months. Testimentary letters from customers indicate that more than $30 million reduction in electrical energy bills have occurred as a direct result of using the SMARTSTAT control. It is believed that product concept recognition is being established and market penetration could accelerate. An example of this results from 2 years discussion with power companies. On Wednesday. April 28, 1982, one large electrical distributor concluded that a $50 rebate and 10 percent interest cost will be given to each customer who installs a SMARTSTAT.

B. ENERGY MANAGEMENT

An example of energy management addresses a different problem of the electrical energy distribution system. Peak energy demands occur in most communities between 6:30 a.m. and 9:00 a.m. (Peaks also occur at other times.) Electrical power stations must have generating capacity to accommodate the customer peak demand whenever it may occur.

This situation leads to very large capital investments for generating systems which are used only spasmodically as peaks occur. Peak load systems are less efficient and more costly to operate, thereby increasing fuel consumption and increasing consumer costs.

A second NSI product, the SMARTSWITCH, has been developed to reduce the peak loads. Engineering departments and consultants of electrical distribution systems have produced analyses that forecast 9 percent to 12 percent consumer billing cost reductions.

Consultants for one municipality have recommended that the SMARTSWITCH be installed for 10,000 customers. The municipality would realize 100 percent return on investment in less than eight months and also delay a $20,000,000 capital investment in generating capacity.

There are tens of millions of potential installation points for the SMARTSWITCH. Considering a modest example that only 200,000 have been installed, the forecast savings will exceed $25,000,000 per year.

C. ENERGY MONITORING

Within their premises, consumers do not know how energy is consumed nor the costs involved. An inexpensive microcomputer electrical energy monitor has been developed. (This monitor can be attached to the system without the skills required to make electrical installations.) More than 8,000 have been sold. This instrument can measure and report to the consumer many conditions such as: rate of energy consumed, amount of energy consumed since the last bill, cost of energy used per day, cost of energy used since the last bill, et al. Also, the monitor can turn off selected devices when they are not needed. Knowledge of energy costs will give the consumer opportunities to plan his energy utilization.

INNOVATIVE NUCLEAR TECHNOLOGY

NSI was created in the early 1950's to develop innovative products using nuclear materials which emit gamma rays. The first application was nondestructive testing of welded metals utilizing the process known as isotope radiography. This technique is applied on cross-country pipelines, pressure vessels in chemical process industries and power plants, structural steel in buildings and bridges, shipbuilding, et al. NSI has achieved worldwide recognition for its radioisotope products.

Other small companies developed applications of nuclear technology, especially in medical science, for example in cancer therapy, radioimmunoassay, thyroid function, et al. Several million patients each year are beneficiaries of these nuclear techniques. Consumer products which, in some way, are being manufactured using nuclear technology include automobile tires, cigarettes, and paper.

Continued development of innovative nuclear technologies has been eliminated by regulatory agencies in the United States.

There is major public concern over the "so-called" nuclear wastes being generated in nuclear power plants. Innovative technology can turn these nuclear wastes into a national resource having very, very large financial gains. To attain these gains, a vast store of knowledge already exists. Unfortunately, these data, produced in the United States 20 years ago, cannot be used because of several government agencies. Foreign countries do not have similar obstructionist policies and are commercially distributing products for human consumption. The many countries which permit food irradiation include Canada, Israel, France, Italy, and Japan.

Someday, Innovation Technology in the U.S. will overcome regulatory agency/public opinion barriers and shall then benefit from the nuclear energy which is now classified as waste from nuclear power plants. The multitude of possibilities is vast, therefore examples will be cited using only two radioisotopes:

A. ENERGY SOURCES

(1) *Oil Reserves Stimulation:* Thermal energy for enhanced crude oil recovery could be provided by the ^{90}Sr capsule which, as a beta emittor, releases 1 kW energy/150 kCi capsule.

(2) *Arctic Villages Program:* Thermal energy in the remote villages is the next most precious commodity to life itself. The use of WESF capsules for water point and sanitation facility heating could have a very favorable impact on the currently poor lifespan probabilities of these people.

(3) *Radioisotopic Thermoelectric Generators:* The use of the low-quality heat from 90Sr to produce electricity has been demonstrated in space and in remote terrestrial applications such as navigational beacons. One such beacon has been operational since 1965.

B. IRRADIATOR SOURCES

(1) *Pest Control:* The use of radiation in the sterile male release technique of pest control has enabled effective control of the screw-worm problem in the cattle industry. This technique can be real help in controlling outbreaks of Mediterranean fruit fly which can quickly destroy the agricultural economic base of an area.

(2) *Shelf-Life Extension of Food:* Gamma irradiation can extend the shelf-life of many foods and could be a real boon to the third world, where almost half the food grown is lost between harvest and the table. A number of foods have been approved by the WHO for treatment to prevent sprouting, mold or spoilage. Millions of people will be impacted by a positive implementation of these programs. Almost every

nation in the world participates in this research and significant achievements are being posted.

(3) *Disinfestation:* Chemicals currently in use for disinfestation are becoming suspect concerning their carcinogenity and mutagenicity. In the U.S. the pesticide Ethylenedibromide (EDB) is being reviewed in this regard and gamma irradiation is being suggested as an alternative to its use in the food chain.

(4) *Sewage Treatment:* Many of the nation's streams are polluted (especially in Louisiana) because sewage treatment plants are not adequate. Data already exists which shows that the following are feasible:

(a) Radiation can eliminate bacteria, viruses, fungi, and parasites from sewage plant effluents.

(b) Radiation can produce ozone for replacing chlorine in sewage treatment. (Also, this would eliminate hazards to the general public which result from transportation of chlorine.)

(c) *Sewage Sludge:* Radiation can eliminate pathogens from sewage sludge. The sludge can then be used as fertilizer for plant nutrition and also as a food supplement in animal feed.

(5) *Gasoline Supplement:* Recent results developed by researchers of the Louisiana State University Nuclear Science Center and the Southern Research Institute indicate that gamma radiation may be effective in converting biomass wastes into ethanol. This can be used as a supplement in or substitute for gasoline.

CONCLUSION

These selected energy products (SMARTSTAT) and SMARTSWITCH) clearly indicate that small companies can develop products, attain and sustain viable operations, and (even in limited operations) implement actions for cost savings and fuel savings valued in tens of millions of dollars—with much growth imminent.

Some of the these selected nuclear projects are already being used and have proved to have values measured in tens of millions of dollars. Starting more of these nuclear projects can have impacts of massive proportions when considering control of insect damage to fruits and grain foods, extending shelf life of foods, and sewage treatment to eliminate dumping pathogens into streams as well as producing plant and animal nutrients from sewage sludge.

The first conclusion to be drawn is that Innovation Technology has already produced results which conserve natural resources and also have positive social and economic benefits.

The second conclusion to be drawn is that Innovation Technology can continue to produce results that can have favorable nationwide and worldwide results.

NSI Corporate Headquarters,
Baton Rouge, La., May 25, 1982.

Mr. Tom Powers,
Small Business Committee,
House Office Building, Washington, D.C.

Dear Mr. Powers: Thank you for the telephone call this morning which was related to Innovation Technology. As requested, enclosed are two copies of advertising material which were alluded to in my discussion: 1.) SMARTSTAT (Energy Conservation); 2.) SMARTSWITCH (Energy Management); and 3.) Dupont Instrument (Energy Monitoring).

My reference to an electric public utility can now be released. The utility is: Houston Lighting and Power, P.O. Box 1700, Houston, Texas.

General features of the program as I understand them at this time are: (a) 10 percent cash rebate to consumer from Houston Lighting and Power on a one-time installation of energy conservation equipment which costs in the range of $200 to $1,000; (b) 10 percent interest on financing of equipment.

It is my understanding that other utilities are planning similar incentive programs. Additional information will be sent to you if you are interested.

Please call me if my assistance may be useful.

Sincerely,

Harry D. Richardson,
Chief Executive Officer.

Mr. Mitchell. Thank you, sir, and thank all four of you gentlemen, again.

There have been so many spurious charges and distortions against this bill, and bad allegations. One such allegation is that if the small businesses do the research they are going to charge more. It will be more expensive because they have to look at their profit margin.

The other side is that the universities to the best of my knowledge always came in with some indirect costs. It might well be that the indirect costs are almost the same as any profit that a small business would make. All four of the members of the panel, would you care to comment on that situation, that it is more expensive to do research by small businesses because they have to make a profit, especially Mr. Richardson who has been on both sides of the aisle here on this whole business of the indirect costs that the universities charge.

Mr. **Richardson**. Since Milt Stewart brought it up so pointedly, I can assure you that any of those of us that have ever been involved in university administration do not have any question that the persons who bring in the grant and contract funds have an extremely difficult proposition of trying to get any access to those overhead funds.

They generally go back to the general fund of the university. Then you have to get in line with everybody to try to have any access to any of it.

To speak to your particular point, on the cost, I would suspect that the small business activity is so intensely oriented to results that they do not have any choice. They are judged every time that they turn in a report as to whether or not they will get any additional funding.

That is not necessarily true in the academic community because he is judged on his performance by his peer group. And that is determined by his distributing papers, and whether or not he will go on an additional panel.

I have the general feeling you will get more productivity from a small business headed toward a product end result, because that is not directly a university function anyway.

Mr. **Mitchell**. Do any of you other gentlemen care to comment?

Mr. **Walters**. I think you would probably find where there is a single major instrument involved, a capital investment that has taken place over quite a few years, that the university probably could underprice a small business if the small business had to go secure such an instrument or something like that.

And there are examples of where applied research and testing and quality control really depends upon that. But by far, the greatest frequency of incident would take place on the other side where the small business would undersell what the university has. They do not have the same overhead, they do not have the same ongoing kind of costs.

Mr. **Mitchell**. Mr. Tarpley.

Mr. **Tarpley**. One of the things we are trying to do at Georgia Tech is to develop a partnership between university-based resources and personnel, and small businesses, and larger business, too. One of the problems with much of the overhead items in the research activities at the university is that much of the cost is capital cost, and that they are not being fully utilized.

One of the areas which is very fruitful is to develop some new and creative interaction among small business and university based researchers where access is given to small business, for that matter, too, to the expensive instrumentation and capital items that are on the university campus.

By working together we can reduce the cost to both the university by sharing the cost of maintaining these items, and to small and large business alike by not having to replicate resources which already exist.

Mr. **Mitchell.** Mr. Green, do you care to comment?

Mr. **Green.** I am under the impression that it is widely believed that small businesses in general are much more efficient, and hence, more cost-effective in research than are large businesses.

In comparing the small businesses to universities, I think the picture is not quite as clear. However, when one is purchasing research or research and development, the end product which is fairly intangible is so sensitive to the interest and motivation of the worker that probably the costs are much more sensitive to the motivation and interests of the individuals performing that research and development than they are to the overhead rate, or whether or not there is a 7- to 10-percent fee on the work.

Mr. **Mitchell.** Thank you.

Gentlemen, thank you for your patience and your testimony. It has been a long, hard day so far today, but well worth it. I think all of us have benefited in a singular fashion from the testimony we have received.

Thank you very much.

At this point, I think it is time to adjourn the hearing, and it is adjourned.

[Whereupon, at 2:20 p.m., the committee adjourned, to reconvene subject to call of the Chair.]

[Statements for insertion in the hearing record follow:]

STATEMENT OF

WALTER J. "PAT" KANE, PRESIDENT
APPLIED DATA COMMUNICATIONS

to the

House Committee on Small Business
May 4, 1982

Summary

- AEA is the largest association of high technology electronics firms in the nation. More than 60% of our companies would qualify for the "protection" offered by H.R.4326/S.881, yet we strongly oppose the bill.

- AEA is being attacked for its position on this bill because it is easier to attack us than to defend a badly drafted bill on its merits.

- Because of our position on this bill a House Small Business Committee Staff person has attacked us in the press as "a bunch of ideological sons of bitches"; another association charges we do not speak for our small companies; and Senator Rudman charges we are "controlled by major corporate interests".

AEA American Electronics Association
1612 K Street, N.W., Washington, D.C. 20006

STATEMENT OF
WALTER J. "PAT" KANE, PRESIDENT
APPLIED DATA COMMUNICATIONS

TO THE
HOUSE COMMITTEE ON SMALL BUSINESS
MAY 4, 1982

Mr. Chairman my name is Pat Kane. I am President of Applied Data Communications in Tustin, California. ADC is a microcomputer systems manufacturer selling equipment and service primarily to disk drive manufacturers and users. We also sell systems and service to flexible media manufacturers and users. We derive approximately 25% of our revenues from export sales and presently employ 60 people.

I am submitting this statement in my capacity as Chairman of AEA's Small Business Services Committee. My Committee has been, and continues to be the source of AEA's position opposing additional special interest set-asides, including those for small business R&D. I oppose this bill for the reasons we have outlined before the Science & Technology and Armed Services Committee.

In this statement I want to set the record straight on some of the charges that have been made against our Association in the course of the debate over this bill.

The Accusations

A staff member of the House Small Business Committee has attacked us in the press, calling us "a bunch of idealogical sons of bitches". Another association charges we don't represent the true views of our small companies because we didn't poll them, while that association has polled its members. And Senator Warren Rudman has charged that we are "controlled by major corporation interests" because 18 of 23 companies on our Government Affairs & Government Procurement Committees are listed on the New York or American Stock exchange.

Why AEA is being Attacked

It's fair to point out that the fact we are being attacked, both as a group and as individuals says alot by itself. We think it's happening because it's a lot easier to attack us than it is to defend a badly drafted bill on its merits. If the bill's proponents had a strong case on the merits they wouldn't waste their time attacking us. The fact that the largest association of intended beneficiaries opposes this bill is relevant, but there are so many other powerful problems with it that we think these attacks are really diversions to avoid discussing the merits. Nevertheless we will attempt to respond with the facts.

I. Are we "a bunch of ideological sons of bitches"?

Mr. Chairman, nearly every businessman you ever heard says he opposes federal intervention in the marketplace. We have certainly said so many times in the past without exciting any surprise or indignation. Our heresy this time it seems, is to have persisted in saying so in the face of a proffered subsidy.

Nearly a year ago we informed the Senate Small Business Committee staff that we strongly opposed the set-aside approach in S.881. Last August we wrote Senator Rudman and detailed our objections. Neither the Senate nor House Small Business Committees ever, invited us to testify on this bill. But what both committees did do is specifically cite our association and our member companies' data in their Committee Reports' explanation of the need for the bill. My AEA colleague and fellow witness Ed Zschau is also mentioned by name.

Knowing we oppose the bill, both Committees still used us to support it. That should suggest to you just how weak the support for this bill really is in the high technology community. It certainly does explain why the staff now finds our views so inconvenient.

2. Can we speak for our small companies without polling them?

Of course we can. The American Electronics Association is a geographically disbursed organization with local "councils" in thirteen separate areas across the country. Member companies in these councils elect directors to represent them on the AEA Board. At present, we have 45 directors on the Board. The Small Business Services Committee which I chair is a subcommittee of the AEA Board, comprised entirely of Board Members who are presidents of companies with 300 or fewer employees.

We are a representational organization, the same way Congress is. Congressmen work hard to stay in touch with their constituency, but do not purport to poll them on every important issue that arises. Neither do we. When there is disagreement within our membership on an issue we try to resolve our differences as much as possible. But when our members split we decide our positions on the merits of the issue - just as Congressmen do.

This willingness to speak up for what we believe is right even if there is disagreement is so fundamental to what AEA is we have embodied it in our Association's formal statement of "Purpose and Objectives". The relevant portion of that document reads:

> Small and large companies make up the AEA membership. As the industry is comprised of companies of all sizes, the balance in the AEA membership represents a more effective voice. We will actively take stands on issues that support our fundamental purpose, even if these issues are controversial and potentially invite criticism from some member companies. We will not promote the special interest of small groups of companies, whether these groupings represent size, industry or geographical interest, except where those special interests support our fundamental purpose. (emphasis supplied)

This has meant that occassionally we take positions that some members oppose. For example, over the last two years we worked hard to inact the Incentive Stock Option. Our small companies badly needed this incentive to compete with larger companies for high level technical talent. Some of our large company members opposed the bill because of the "brain drain" it could create for them. Other members opposed it because Incentive Stock Options increase the income taxes of the companies which use them. But we knew we represented the best interest of our industry as a whole when we pushed for the Incentive Stock Option; just as we believe the best interest of our industry now lies in opposing the SBIR bill.

How We Decided the SBIR Position

In 1980 the Chairman of the Small Business Services Committee asked the AEA Board to oppose formally creation of any new special interest set-asides in federal procurement, specifically including those based on company size. The resolution did not seek repeal of existing set-asides but asked the association to speak out against any additions to the list. The Board adopted the proposal. We realized at the time that the decision would be controversial. Therefore the Board decided to offer every company an opportunity to comment on it. So we published a description of the Board's action and a request for member comment on the front of our June 1980 Procurement Bulletin which went to every company. (Copy attached). Only five companies responded and four of those agreed with the new policy.

When S.881 began to move in the Senate, we informed Senator Rudman of our opposition to further set-asides. Late last year we were asked to testify by the House Science and Technology Committee and took the matter up once again. My committee examined the bill and voted unanimously to oppose H.R.4326/S.881. The full AEA Board then adopted our position and voted to testify against the bill.

Questions On The EAC Poll

But though AEA does not decide its issue positions through polls, other associations do. Those groups have an obligation to draft and tabulate their polls to be as valid as possible. If the results are to be credible they must present the pros & cons of an issue to their members clearly and without biasing the results. In the case of the EAC poll which is being used to challenge AEA's position on this bill, we hope the Committee will decide for itself whether that was done. We hope you will examine the questionnaire itself and determine whether this was a valid "poll" or a manipulation of information designed to elicit a pre-determined response.

3. Are we "controlled by major corporate interests" as Senator Rudman charges?

After three years on the AEA Board, representing a small company, I do not find that the large companies control the association. The Senator charged that our Government Affairs and Procurement committees are predominantly made up of large company representatives and he is correct. He errs though in calling them "controlling committees."

These committees are primarily made up of corporate specialists in Procurement and Government Affairs. They report to the AEA Board through their Committee Chairmen who are not voting members of the Board. The AEA Board itself is comprised of 45 CEO-level people from thirteen regions across the country. 53% of the Board (24 people) are from companies with 1,000 employees or less, and 40% (18) are from companies with 500 employees or less.

For the record, the large companies do not dominate the association's finances with their dues either. No one company pays more than .0028% of the association's annual budget through its dues.

There's no mystery on the source of AEA's position opposing this bill. It did not stem from the Procurement or Government Affairs Committees. My Committee developed it and the Board which every member of my Committee serves on adopted our recommendation.

Governmen
Procuremen
Bulletin

Vol. III, No. 2

June 12, 1980

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Prime R&D Set-Asides To Small Businesses May Rise

Federal procuring agencies would be required to award 1 percent of their prime R&D contracts to small businesses in fiscal year 1981 under legislation approved recently by the House Small Business Committee.

The bill (H.R. 5607) increases set-asides by 1 percent each year until 15 percent of such contracts go to small businesses. Originally, it called for procuring agencies with R&D budgets of $100 million or more to increase set-asides by 2 percent annually until 20 percent of their R&D funds were funneled to small business.

The Senate Select Committee on Small Business has approved similar legislation (S.1806) which sets a 1 percent annual increase rate with an ultimate small business set-asides figure of 10 percent.

Neither bill has reached the floor of its respective house, although Senate action may take place sometime this month. Both bills were specifically endorsed, in Recommendation 11, by the White House Conference on Small Business.

The Conference's Recommendation 30 urges Congress to adopt legislation establishing separate mandatory goals for general procurement set-asides for small business. This would be done on a contract-by-contract or agency-wide basis. Proposed goals are 35 percent for small businesses, 15 percent for minority-owned businesses and 10 percent for businesses owned and controlled by women.

Legislation to implement Recommendation 30 has been introduced but is not moving. Executive action to implement the goals—or some lower and more attainable figure—is encountering stiff, united opposition from procuring agencies concerned with cost, value and reliability issues arising from use of small businesses.

Members' Views Sought

Association action on the issue of further government set-asides for small business has itself been set aside to give AEA members an opportunity to express their opinions as a guide to any Board decision.

The Association's Small Business Services Committee recommended to the Board of Directors at its meeting last month that any further increase in the set-asides be opposed.

This stemmed from AEA's opposition to growing government intrusion into business, a position the Board reaffirmed. However, the Board would like to hear the membership's voice on the matter before deciding on what action—if any—should be taken by the Association.

Comments should be addressed to: AEA Government Operations Department, 2600 El Camino Real, Palo Alto, CA 94306.

MAY 12 1982

PUBLIC AND SCIENTIFIC AFFAIRS BOARD

AMERICAN SOCIETY FOR MICROBIOLOGY

1913 I Street, N.W.
Washington, D.C. 20006
Telephone: Code 202, 833-9680

May 11, 1982

The Honorable Parren J. Mitchell
Chairman
House Committee on Small Business
U.S. House of Representatives
Washington, DC 20515

Dear Chairman Mitchell:

The Public and Scientific Affairs Board (PSAB) of the American Society for Microbiology (ASM) wishes to submit the following additional remarks for the record concerning the Small Business Innovation Development Act (H.R. 4326). First, our views basically have not changed, and remain as stated in our letter of 21 December 1981 (copy enclosed).

Although we favor some type of support or encouragement to small businesses, we still oppose the philosophy of a set-aside for the following reasons:

1) Research grants should be awarded solely on the basis of merit, not because of legislation which discriminates between scientists on the basis of where they work. The set-aside amounts to a special entitlement for scientists who work for small businesses, and we must oppose such discrimination.

2) The set-aside provision is not needed because scientists and small businesses can now freely and easily compete for National Institutes of Health (NIH) research grants. Although late in coming, the following changes by NIH enable equal competition:

   a) Scientists from small businesses may now apply for research grants.
   b) Scientists from for-profit firms will be added to peer review panels at NIH.
   c) For-profit firms may now retain patents on inventions supported by Federal funds.

   Those scientists and small businesses who still question the sincerity of NIH should be able to rely on appropriate available Congressional oversight committee activity.

3) Small business firms received $30 million out of the $369,151,000 awarded by the National Institutes of Health (NIH) for R & D contracts in fiscal year 1981. This represents 8 1/2 percent of the total amount awarded for R & D contracts.

4) Additionally, it is our opinion that NIH, following the enactment of the Federal Grants and Cooperative Agreements Act of 1977 (P.L. 95-224), moved judiciously to open the grants system to for-profit firms. Originally it was as a direct result of pressure from Congressman L. H. Fountain, Chairman of the Intergovernmental Relations and Human Resources Subcommittee, that the Public Health Service in the early 1960's issued regulations prohibiting for-profit firms from competing for research grants at NIH. It is reported that Congressman Fountain's investigation turned up misuse of federal funds by at least one for-profit firm.

5) A set-aside provision is not needed because we believe that few if any scientists in small businesses will apply for grants for basic research in the life sciences. They would be almost exclusively in applied research and development contracts. Small businesses are for-profit firms, and basic research by definition is not associated with or predicated upon a practical end product. Rather, the fruits of basic research are concepts and ideas. Thus, basic research grants are usually of most interest to scientists from universities and not for-profit research institutes, while applied research and development contracts are of special interest to scientists from for-profit businesses and organizations. We feel that the set-aside will seriously and unfairly tax basic research, especially in the life sciences.

Part of the difficulty with this legislation rests on a lack of understanding of basic research. Basic research aims at the creation of new ideas and concepts without any particular thought given to practical end products, let alone commercial applications. Basic research is very expensive and therefore usually relegated to scientists in large non-profit institutions (universities and non-profit research institutes) and is heavily supported by federal funds. Basic research is usually investigator-initiated and delves deep into fundamental processes, from which sometimes emerge new ideas and concepts in a largely unpredictable fashion. These new concepts may have wide ramifications, and they may be exploited by industry for the public good through appropriate applied research and development. Applied research and development applies the concepts of basic research to the solution of specific mission-oriented tasks. Basic research is not oriented to specific missions.

It provides the foundation for the development of high-technology and a better way of life. Impairment of basic research would indeed be tragic.

The recent announcement that insulin for human use was being manufactured by one of the new biotechnology, recombinant DNA industries is perhaps a good example. These industries are based upon fundamental knowledge and concepts generated through basic research conducted several years ago by several scientists who were studying the manipulation of bacterial genes. At this time, this research was rather far-out and not of great general interest. It certainly had no profit motive, and it could hardly have fulfilled a mission requirement for any Federal agency. However, it provided basic information of various mechanisms to introduce bacterial genes into other kinds of bacteria, and more recently to clone animal genes in bacteria. Nevertheless, these ideas and information from basic research had to be applied specifically to bovine or human insulin to see if the genes for insulin synthesis could be introduced into bacteria. Positive results of this applied research have yet to be developed for efficacy and safety in the human by appropriate clinical trials, which I understand are currently in progress. It all started with basic research.

It should be obvious that we consider HR 4326 a bad bill for basic research and bad for the public. The Waxman Amendment would exclude NIH from the provisions of this bill and remove most of our fears for basic research. However, if the bill still moves through the House as it now stands we would also favor the Fuqua Amendment to subject all agency funds for SBIR programs to normal Congressional review by the authorization and appropriations committees. Of equal importance, we would urge that all funds earmarked for basic research be excluded from SBIR programs.

Although the Schmitt Amendment moves in the right direction in excluding all but 1% of NIH research grants, we feel that all basic research should be excluded. One percent is a "foot in the door" to which basic research should not be subjected.

Please let us know if we can be of any help in your deliberations.

Sincerely,

C. D. Cox

C. D. Cox, Ph.D.
Chairman, Committee on Medical
Microbiology and Immunology, PSAB

PUBLIC AND SCIENTIFIC AFFAIRS BOARD
AMERICAN SOCIETY FOR MICROBIOLOGY

1913 I Street, N.W.
Washington, D.C. 20006
Telephone: Code 202, 833-9680

21 December 1981

The Honorable Henry A. Waxman
Chairman, Subcommittee on Health
and the Environment
Committee on Energy and Commerce
U.S. House of Representatives
Washington, D.C. 20515

Dear Mr. Waxman:

The Public and Scientific Affairs Board (PSAB) of the American Society for Microbiology (ASM) wishes to convey to you its concern about the Small Business Innovation Development Act of 1981 (HR 4326). This bill, together with Senate bill S 881, has been under study by this Board, and we wish to communicate our fear that both bills would be harmful to the basic biomedical research effort in this country.

The American Society for Microbiology has an active membership of over 31,000 individuals and is the largest single life science organization in the world. We wish to stress at the outset that ASM represents member microbiologists, whether they are holding research positions in large industry, small businesses, research institutes, or universities. We recognize that competition and free enterprise are cornerstones of our economy, and we feel that these concepts should extend to the awarding of research grants and contracts by federal agencies. Microbiologists working in small businesses should have equal opportunity to compete for research grants and contracts with their counterparts in universities, etc. Our understanding is that such is now possible with respect to National Institutes of Health (NIH) grants and contracts. However, mandating that research be set aside for any one class of organization, whether it be small businesses or universities, would constitute these awards being made on other than an impartial basis of merit, and we would oppose such a system.

The international recognition of the extramural NIH research program has resulted largely from their peer review system, which strives to assure that awards are made only on the basis of merit. This also assures that the public dollar is spent where it has the best chance of success. HR 4326 mandates a set-aside for small business firms and lacks provision for adequate peer review equivalent to that existing currently for research grants.

About 70 percent of microbiologists and other biomedical scientists in non-profit institutions, who have their applications for NIH research grants approved on the basis of scientific merit, are not funded because of insufficient money. Legislation that would mandate a set-aside of 3 percent of the NIH budget for research grants to only those scientists in small businesses is blatantly unfair. Legislation which also gives these favored few the additional advantage of not having to compete for funds in the same peer review system is bad legislation and we cannot support it.

We are sympathetic to the notion of incentives for small businesses, but the incentive in this instance is to the detriment of basic research. These are difficult times for basic research in the biomedical sciences, and the amount of the set-aside is significant. Basic research generates new ideas, concepts and products which industry and business can exploit for the public good. To legislate for a set-aside which will adversely affect basic research makes no sense at this time. We do not feel that significant numbers of basic research scientists, in contrast to applied research and development scientists, are in small businesses. Thus funds will be diverted from basic research to development or not spent at all.

We could suggest amendments which would tend to mollify the adverse effects of this bill. In our opinion, the amendments made to the Senate bill are inconsequential. We could suggest that 3 percent is too high, and that the base should be only the extramural research funds rather the total agency budget. We could suggest that current set-asides be included and that set-aside funds not expended be available for those applicant organizations that compete on a free and non-favored basis through an accepted peer review process. Such amendments would lessen the blow, but we must reaffirm that we would still oppose legislation which would detract from basic research. We do not feel the country can afford this, and we basically oppose legislation favoring one class of scientists while discriminating against another.

The Public and Scientific Affairs Board of the ASM welcomes the opportunity to make its thoughts known to you, and we stand ready to work with you in any way we can be helpful.

Sincerely yours,

Frederick C. Neidhardt

Frederick C. Neidhardt, Ph.D.
President, ASM

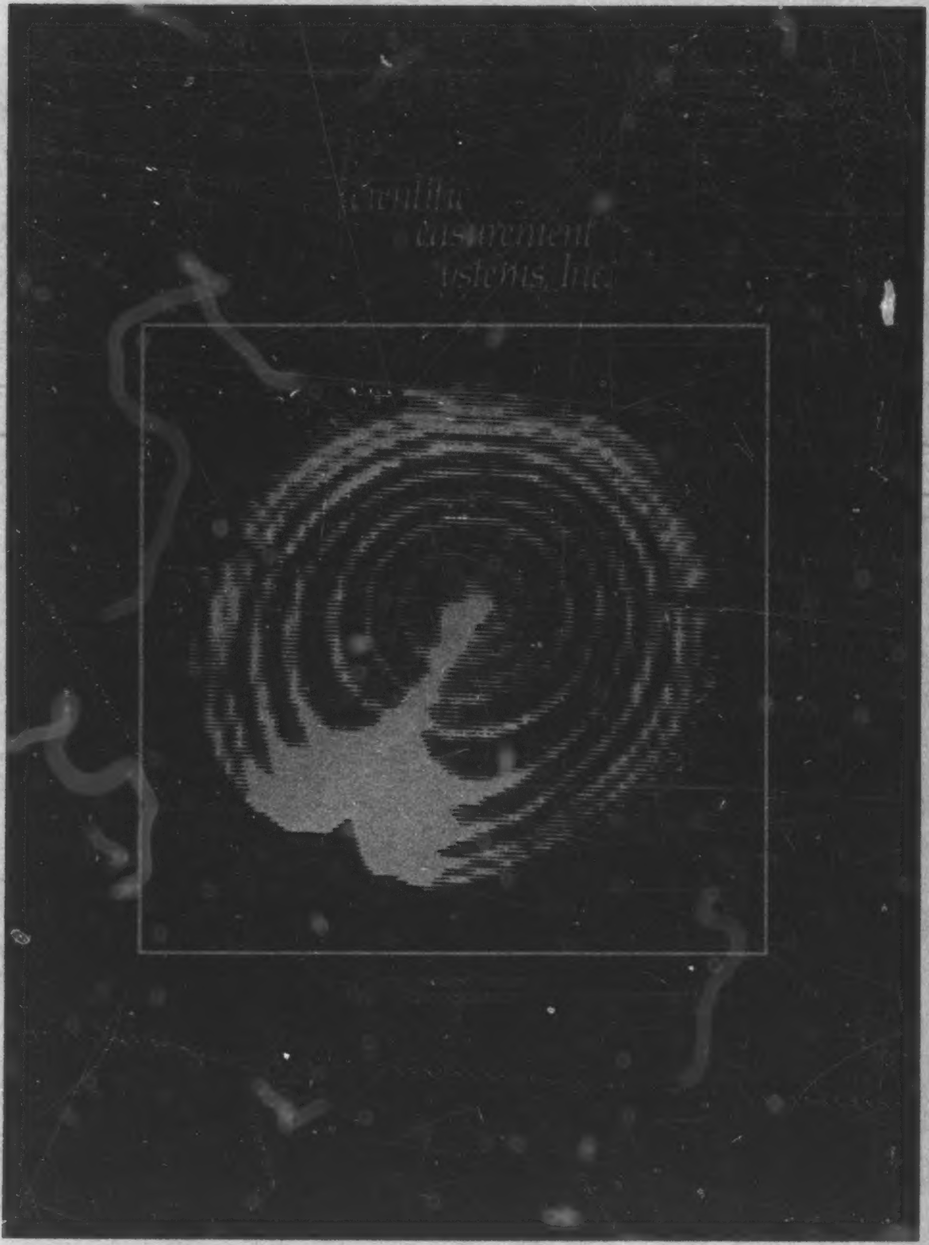
Harlyn O. Halvorson

Harlyn O. Halvorson, Ph.D.
Chairman, Public and Scientific
Affairs Board

C D Cox

C. D. Cox, Ph.D.
Chairman, Committee on Medical Microbiology
and Immunology

ag
cc: Honorable John D. Dingell
Honorable Don Fuqua
Honorable Doug Walgren
Members, Committee on Energy and Commerce
Members, Committee on Science and Technology
Members, House Committee on Small Business
Members, Senate Committee on Small Business



cientific
easurement
ystems, Inc.

Scientific Measurement Systems, Inc.

Computerized Industrial Tomography

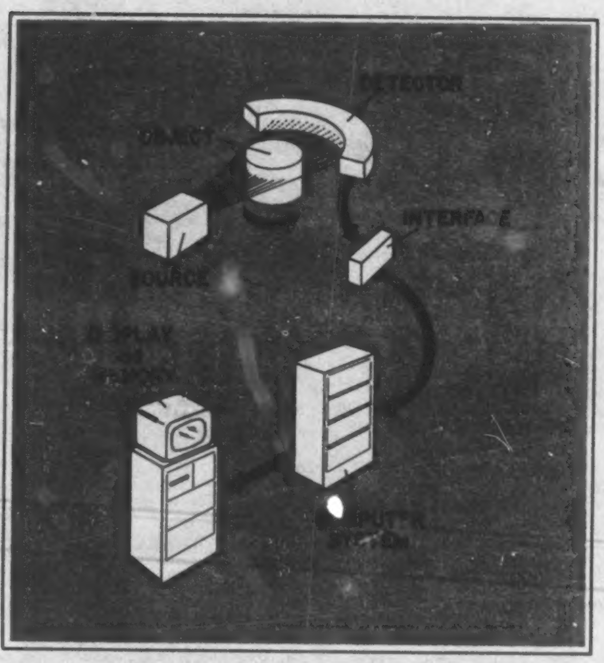
The Company

Scientific Measurement Systems, Inc. was founded in 1979, to design and manufacture tomographic systems for industrial applications. Located in Austin, the high-technology center of the Southwest, SMS has grown from a small group of scientists and engineers to a manufacturing firm capable of designing, building and servicing systems for companies worldwide.

SMS is continuing to grow and become a significant factor in the nondestructive testing field. The SMS Laboratories are continuously improving on technology for their computerized industrial tomographic devices to be used in such critical fields as metals, plastics, timber, concrete and ceramics in all types of structural, mechanical, electrical and chemical systems.

Tomographic Technology

Computer assisted tomography is a method of nondestructive inspection by which the interior structural densities of an object can be determined very accurately without harming, modifying, or contacting the object. Objects are examined in a series of cross-sectional slices which are usually displayed by a computer as pictures on a television screen or printed out as hard copy. Each slice/picture ("tomogram") is formed by calculations based on measurements of radiation transmitted along multiple paths through the object. These measurements are made by moving the radiation source and detectors across and around the object being examined. This process allows the detection of features from 0.040 to 0.001 inches depending upon the density difference between the feature and its surroundings.



Tomographic Scanner Operation

The use of tomography was pioneered in astronomy and later in the medical x-ray field where systems are popularly known as CAT (or CT) scanners, an acronym for "Computerized Axial Tomography." The operation of a typical tomograph is illustrated in the block diagram shown above.

An object whose internal structure is to be studied is positioned between a radiation source and a set of detectors. The source contains either a gamma ray emitting isotopic source, such as iridium 192, or a high intensity x-ray tube. The source is highly collimated to form a fan-shaped beam of photons directed at the object.

The detectors receive the photons that pass through the object, and each generates a signal that is processed by the computer. The number of photons received by the detectors compared with the number emitted by the source is a measure of the density, or photon opacity, of the object. Rotating the object relative to the source and the detectors, or vice versa, and obtaining transmission data through the object at a number of angles, the computer derives enough information to calculate a two-dimension density map of a slice through the object. Three-dimensional information is generated by taking successive scans along the length of the object. Each two-dimensional slice, or tomogram, may be projected for viewing or recording on the display unit.

Use of Scanner Evaluations

The results of a tomographic examination can be used in several ways.

Visual Examination

The data collected during an examination is usually assembled into a cross-sectional pictorial display of the object known as a tomogram. A tomogram is generated by the system computer and is made up of a matrix of picture elements called pixels. The matrix is usually a square of 100 to 1000 elements on a side. The pixel size is chosen to be smaller than the feature to be resolved, and may be as large or small as desired. Each pixel is assigned a shade on the gray scale ranging from black to white depending upon the average density in the corresponding area of the object. Black corresponds to lowest density and white to the highest. The average density represented by a pixel is represented in the computer memory by a numerical value calculated from the results of the scan.

A tomogram may be examined visually and interpreted by an operator or scientist. Characteristics such as knots in logs and cracks in concrete are easily seen. If certain features do not stand out sufficiently, the relative contrast can be changed simply by assigning different gray scale values to each pixel. Particular levels of density can also be highlighted by shading those pixels black to form contour lines. If a closer view of a feature is desired, it is a simple matter to do a computer blowup of the area of interest. It is often useful to obtain "before and "after" comparisons to assess changes within an object, such as the progression in time of a crack within a structural element. Two tomograms taken at the same location can be differenced and a new tomogram showing only those differences can be generated.

Quantitative Analysis

Since a tomogram is quantitative, the information contained in each pixel can be processed mathematically. The results of this processing may be displayed graphically, printed out numerically, or stored for use by other analytical methods.

The most common mode of graphing a tomogram is as a frequency distribution of the various densities in an object, known as a histogram. A visual examination of a histogram can be used to spot characteristic anomalies. For example, knots in a log will show up as a secondary peak on the high density end of the histogram. Both the bending and impact strength of an object, such as a power pole or concrete bridge column, can be estimated by determining the modulus, or weighted average, of the histogram.

Another mode of graphic representation is a simple spatial density profile. This shows the variance of the density level across the object. This might be used, for example, to compare the shielding thickness at various points on a coaxial cable or to examine the uniformity of filters.

Automatic Process Controls

The information in a tomogram does not have to be displayed to be useful, but can instead be used to make control adjustment in an industrial process. In the production of steel, for example, completed steel bars can be scanned for dimensional accuracy, weight per linear foot, and delaminations and be automatically rejected if the computer detects an anomaly in any parameter. In a sawmill the tomograph can scan a log and determine the coordinates of knots and automatically determine how to cut the log for the highest grade of lumber. The information from such a process control system may also be automatically assembled into production reports for executives.

Quantitative Flexibility

A computerized tomogram is made up of a matrix of numbers representing densities at each point in the cross section. The digital form of the data permits the use of a number of display manipulations and analytical techniques to be applied.

- Density distributions can be used to calculate strength or to detect characteristic defects.
- Density spatial profiles and mathematical differencing can be used to check conformance of an object to a standard object.
- Averaging techniques can be used to clarify a picture.
- Region of interest display can focus on a particular area of interest.
- Isodensity marking can be used to highlight certain features.
- Particular density levels can be brightened and displayed.
- Picture contrast can be varied to highlight density transitions of interest.

A Versatile Sensor System

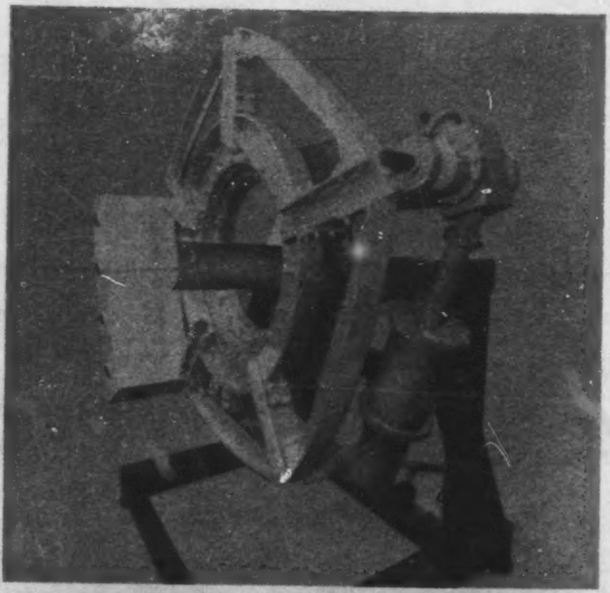
The SMS Industrial Tomograph is a multiple sensor in a single package, programmable to detect most parameters that are associated with density, such as composition, defects, density variations, strength, size, weight, shape and location of the foregoing.

As a result it has the ability to replace many existing systems used in industrial quality control and process control systems and render unnecessary the installation of a large number of separate sensor systems.

SMS Patented Detectors

Through the use of a patented detector system (U. S. Patent 4,284,895), SMS scanners are able to produce tomograms of larger, more dense objects with higher resolution than previous scanners.

The photon counting plastic scintillation detector for tomography provides a very low noise detector that is highly efficient in detecting transmitted high energy photons and rejecting scattered photons. Virtually the only noise in the measurement is the statistical sampling variation, which can be reduced by counting longer if better density resolution is required. This low noise characteristic of the detector is particularly important for the examination of very dense or large objects in which the transmitted signal is very small. SMS scanners have been used successfully on objects with opacities as great as 15 inches of steel.



Computerized Industrial Tomography (CIT) provides the user with the remarkable ability of looking inside a solid or enclosed object to reveal structural details without damage to the object. CIT has innumerable applications in industry both for process control and nondestructive evaluation. A few of these are as follows:

- Wood industry: sawmills process control, inspection of wooden poles, dock pilings and railroad trestles.
- Aerospace industry: inspection of rocket motors, aircraft wings and landing gear, jet engine turbine blades, and satellites.
- Nuclear industry: inspection of fuel rods, waste containers, and pipes.
- Transportation and construction industries: inspect concrete and steel bridge columns and beams, building columns and beams in building walls.
- Petroleum industry: inspect offshore platform legs, high pressure wellhead equipment, drill pipe, drilling rig structural components and pipelines.
- [illegible]: inspect castings and welds, [illegible] power cables.
- Science: new [illegible] programs; inspect valuable artwork, archeological objects.
- Defense: inspect ammunition, security applications.
- Chemical industry: inspect pipes and containment vessels and filters.
- Steel and metals industry: inspect extruded or rolled steel for delamination, inspection of welds and dimension measurement of hot metal during fabrication.

MR. CHAIRMAN AND DISTINGUISHED MEMBERS OF THE CONGRESSIONAL COMMITTEE ON THE SMALL BUSINESS ACT:

IN THE WORKS OF PROFESSOR FLORIAN CAJORI, "A HISTORY OF PHYSICS" (1) AN EXCELLENT HISTORICAL TREATISE IS PRESENTED OF THE INVENTIONS OF THE 19th AND 20th CENTURIES. PARTICULARLY THOSE OF MEN SUCH AS MAXWELL, RONTGEN, PELTIER, BELL AND EDISON WHOSE WORK HAS SO EFFECTED OUR CURRENT WAY OF LIFE.

IT IS INTERESTING TO NOTE IN HIS HISTORY OF RESEARCH LABORATORIES HE STATES:

> "IN A HISTORY OF THE ROYAL SOCIETY OF LONDON WRITTEN IN 1667, THE AUTHOR DEEMS IT NECESSARY IN ALL SERIOUSNESS TO DEFEND EXPERIMENTATION, ARGUING THAT 'EXPERIMENTS WILL NOT INJURE EDUCATION,' THAT 'EXPERIMENTS (are) NOT DANGEROUS TO THE UNIVERSITIES.' THE ARGUMENTS WERE NECESSARY INDEED, FOR THE OXFORD PULPIT DECLARED THAT ROBERT BOYLE'S RESEARCHES WERE DESTROYING RELIGION AND HIS EXPERIMENTS WERE UNDERMINING THE UNIVERSITIES.
>
> THE ADVENT OF THE EXPERIMENTALIST MARKS THE ORIGIN OF LABORATORIES. WE DO NOT MEAN LABORATORIES OF THE MODERN TYPE. PREVIOUS TO THE NINETEENTH CENTURY ALL OF THEM, WITH HARDLY ANY EXCEPTION, WERE PRIVATE LABORATORIES OWNED BY INDIVIDUAL INVESTIGATORS OR THEIR PATRONS."

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(1) Cajori, Florian, A History of Physics, Revised and enlarged Edition, Dover Publications, Inc., New York, New York.

AN ANALOGY IN THIS PERIOD OF TIME IS SMALL INNOVATIVE RESEARCH BUSINESSES. THE INDIVIDUAL LABORATORIES WERE OPEN TO ONLY A FEW ASSOCIATE EXPERIMENTS AND IT WAS NOT UNTIL ABOUT 1850 THAT UNIVERSITIES ESTABLISHED LABORATORIES FROM WHICH MANY DISCOVERIES HAVE EMERGED.

SMALL HIGH TECHNOLOGY FIRMS ARE HIGHLY COMPATIBLE WITH UNIVERSITIES. THEIR IDEAL LOCATION IS ADJACENT TO THE UNIVERSITY AND/OR WORKING CLOSELY WITH THEM. IT ALSO CAN HELP UNIVERSITIES TO KEEP QUALITY FACULTY WHO WORK AS CONSULTANTS TO THEM, PROVIDE FUTURE JOBS, GRADUATE STUDENT WORK, OUTLETS FOR UNIVERSITY INVENTIONS, ROYALTY INCOME. TOGETHER THEY CAN MAKE BASIC RESEARCH IN UNIVERSITIES EVOLVE INTO PRODUCTS AND MOVE ON TO RAPIDLY MEET THE JAPANESE AND OTHER ECONOMIC CHALLENGES.

THEREFORE SMALL S&T FIRMS ARE UNIQUE US NATURAL RESOURCES. FEW OTHER COUNTRIES HAVE THEM. COLLECTIVELY THEY REPRESENT AN ENORMOUSLY IMPORTANT ASSET IN HELPING US TO COMPETE IN TECHNOLOGY, INNOVATION AND CREATE NEW JOBS. COLLECTIVELY THEY ARE VERY IMPORTANT TO OUR ECONOMY OF THE NEXT DECADE.

IT IS SAID SMALL FIRMS CANNOT ABSORB $400 MILLION OF R&D WITHOUT A DEGRADATION OF QUALITY. THIS REPRESENTS AN INCREASE OF ONLY ONE PERCENT TO 1.4 PERCENT OF FEDERAL R&D GOING TO SB AND THREE YEARS TO GET THERE. THERE ARE ABOUT 10,000 SMALL HIGH TECHNOLOGY FIRMS. $400 MILLION REPRESENTS AN AVERAGE OF $40,000 TO EACH OR AN ADDITIONAL $400,000 A YEAR TO THE TOP TEN PERCENT. MOST OF THE BEST COULD ABSORB FAR MORE THAN THIS. YOU COULD DO $10 MILLION

A YEAR ALONE AND STILL BE A SMALL BUSINESS LEGALLY AND REALISTICALLY. IF ONLY 40 FIRMS IN THE WHOLE COUNTRY GOT $10 MILLION OR 400 GOT $1 MILLION--THAT'S THE $400 MILLION. $400 MILLION IN A NATIONAL PROGRAM COULD EASILY BE ABSORBED AND THE QUALITY OF FEDERAL R&D (AS WELL AS QUANTITY) WOULD IMPROVE RATHER THAN DECLINE.

DURING THE PAST 30 YEARS INNOVATIVE RESEARCH HAS LED TO MANY IMPROVEMENTS IN OUR QUALITY OF LIFE AND ECONOMIC DEVELOPMENT. IN TABLE I BELOW IS A LIST OF ONLY A FEW AREAS:

(See Table I next page)

TABLE I

(1) ION IMPLANTATION IN THE SEMI-CONDUCTOR

Industry	Annual Production	Value Added to GNP
(a) U.S.	8.8 billion/yr	17.6
(b) Japan	4.3 billion/yr	8.6
(c) Europe	2.2 billion/yr	4.4
(2) ELECTRON BEAM PROCESSING		
(a) U. S.	3.1 billion/yr	7.0
(3) GEOPHYSICS		
(a) n, γ logging	1.1 billion/yr	110.0
(4) NONDESTRUCTIVE TESTING EQUIPMENT		
(a) QC	0.3 billion/yr	3.0
(b) Process Control	3.0 billion/yr	30.0
(5) NUCLEAR MEDICINE		
(a) Instruments	1.0 billion/yr	10.0
(b) Services	10.0 billion/yr	100.0
		290.0 Billion

THERE IS MUCH ADVANCED APPLICATIONS WORK IN SMALL FIRMS EMERGING FROM BASIC RESEARCH THAT IS IDEAL FOR SMALL HIGH TECHNOLOGY FIRMS IF THE BASIC RESEARCH IS GOING TO MOVE ON AND PAY OFF TO THE U.S. SMALL FIRMS WILL MOVE IT MORE QUICKLY AND AT LOWER R&D COST TO THE MARKET PLACE. REGULATIONS AND AGENCIES HAVE KEPT SMALL BUSINESSES LOW, 3-4 PERCENT VS. SMALL BUSINESS 20-25 PERCENT SHARE OF FEDERAL PROCUREMENT, 53 PERCENT OF ALL JOBS, AND ABOUT 35 PERCENT OF GNP. I SINCERELY BELIEVE FROM LONG-TERM EXPERIENCE THAT THERE IS NO ALTERNATIVE TO REQUIRING THAT AN ADDITIONAL ONE PERCENT OF FEDERAL R&D GO TO SMALL BUSINESS FIRMS.

Ira Lon Morgan, Ph. D.
Scientific Measurement Systems, Inc.
2808 Longhorn Blvd #303
Austin, Texas 78759

May 3, 1982

Resume

IRA LON MORGAN

Birth Date: August 3, 1926

Birth Place: Fort Worth, Texas

Address: 3800 Palomar, Austin, Tx 78759

Married, three children.

Education

B.S., Physics, Mathematics, Texas Christian University, 1949.
M.A.,Physics, Texas Christian University, 1951.
Ph.D., Physics, The University of Texas at Austin, 1954.

Professional Memberships and Committees

American Physics Society (Fellow); Member, Selection Committee for Bonner Prize in Nuclear Structure; Member, Program Committee of the Division of Nuclear Physics.

American Nuclear Society - Fellow
American Nuclear Society; Member, Executive Committee on Isotopes and Radiation Division; Honors and Awards Committee.

Sigma Xi, Sigma Pi Sigma.

American Institute of Management.

United States Atomic Energy Commission Advisory Committee on Isotopes and Radiation Development (Past Chairman).

Former U. S. Atomic Energy Consultant. Member, Nuclear Cross-Section Advisory Committee.

Former Los Alamos Meson Physics Facility, Executive Committee Users Group.

Los Alamos Nucleon-Nucleon Physics Facility, Steering Committee.

National Bureau of Standards Advisory Panel for Center of Radiation Research.

Consultant, Texas Radiation Advisory Committee.

Los Alamos Meson Physics Facility, Program Advisory Committee.

American Physical Society, Committee on Application of Physics.

National Academy of Science, Committee on Nuclear Science.

Professional Listings

American Men of Science
Who's Who in Atoms
Who's Who in the South and Southwest
Who's Who in Industry
Who's Who in America
National Register of Prominent Americans and International Notables.

Civic

Capital Area Radiation and Research Foundation, Board of Directors.

Civitan International, Chapter Civitan of the Year 1958-59.

Austin Chamber of Commerce, President 1967; Past President, 1968; Member, Board of Directors 1966-68.

Great Hills Country Club, Board of Directors, 1974-75.

Seton Hospital, Lay Board of Directors.

Town and Gown. Austin Citizens Committee.

Experience

Physics Instructor, Texas Christian University, 1949-1951.

Teaching Fellow, The University of Texas at Austin, 1951-54.

AEC Post Doctoral Fellow, The University of Texas at Austin, 1954-56.

Vice President and Director of Research, Texas Nuclear Corporation, 1956-61.

Executive Vice President and Director of Research, Texas Nuclear Corporation, 1961-66.

Vice President, Nuclear-Chicago Corporation, 1965-68.

Board of Directors, Nuclear-Chicago Corporation, 1964-67.

President, Texas Nuclear Corporation, 1966-68.

President, Columbia Scientific Industries, 1968-76.

Director, Center for Nuclear Studies, The University of Texas at Austin, 1968-73.

Experimental Research, Center for Particle Theory, The University of Texas at Austin, Dept. of Physics, Austin, Texas , 1976-

Director, Hospital Financial Corporation Laboratory, Balcones Institute for Research and Development, Balcones Research Center, The University of Texas at Austin, Austin, Texas, 1976-77

Executive Vice President, SKM, Inc., Austin, Texas , 1976-

Summary

Physics Instructor, Texas Christian University, 1949-51. Instructor Freshman Physics courses and laboratory; Grader, advanced courses.

Teaching Fellow, The University of Texas at Austin, 1951-54. Instructor in Freshman and Sophomore laboratory courses; Instructor Junior Optics Laboratory course; Research Assistant, Construction of 4.0 Mev Van de Graaff machine and The University of Texas Nuclear Physics Laboratory.

AEC Post Doctoral Fellow, The University of Texas at Austin, 1954-56. Research on Charged Particle Reaction, Neutron Elastic and Inelastic Scattering, Nuclear Structure, Gamma Ray Spectroscopy and Nuclear Instrumentation. Assistant Director of Nuclear Physics Laboratory.

Vice President and Director of Research, Texas Nuclear Corporation, 1956-61. Founder of Texas Nuclear Corporation. As Vice President and Director of Research, responsibilities included design and development of research programs, facilities contract procurement, long-range planning, research and research management, development of nuclear instrumentation products. Company growth increased from an annual rate of $100,000 in 1957 to $900,000 in 1961. Research programs included Nuclear Physics, Biophysics, Radiobiology, and Applied Physics. Products included Particle Accelerators, Nuclear Detectors, and Instrumentation.

Executive Vice President and Director of Research, Texas Nuclear Corporation, 1961-66. Managed all activities of Texas Nuclear

Summary continued

Corporation, Research, Product Development, Manufacturing, Marketing, and Administration. Merged into Nuclear-Chicago Corporation in 1961. Built additional research and manufacturing facilities. Elected to Board of Directors of Nuclear-Chicago in 1964; responsible for corporate long-range planning in Physical Sciences. Elected Vice President of Nuclear-Chicago in 1965. During period, Texas Nuclear growth increased from $900,000 in 1961 to $1,700,000 in 1966. Research activities in X-ray and Atomic Physics and Theoretical Physics were initiated. A product line expansion in Health Physics Instrumentation was marketed.

President, Texas Nuclear Corporation, 1966-68. Managed all activities of Texas Nuclear Corporation, research, product development, production engineering, manufacturing, marketing, and administration. Merged Texas Nuclear and Nuclear-Chicago into G. D. Searle & Co. Built additional manufacturing facilities in 1967, doubling capacity. Growth increased to an annual rate of $2,700,000 with addition of Industrial Process Sensor Product Line.

Professor of Physics and Director of the Center for Nuclear Studies, The University of Texas at Austin, 1968-73. Developed $840,000 funded budget for 63 faculty, staff and graduate students in the areas of Low Energy Nuclear Physics, Medium Energy Nuclear Physics, Atomic and Molecular Physics, Nuclear Astrophysics and Radiobiophysics.

Graduate Research Council, The University of Texas at Austin, 1969-73.

Founder and Chairman, Columbia Scientific Industries Corporation, 1968-1976. Managed all activities of the company for research, product development, acquisitions, manufacturing and marketing of Analytical Instrumentation and Audio-Audio Visual Control Systems. Corporate growth increased from $300,000 to an annual rate of $3,000,000.

Experimental Research, Center for Particle Theory, The University of Texas at Austin, Department of Physics, 1976 to present.

Nucleon Nucleon Scattering, Muonic X-ray Analysis, The University of Texas at Austin.

Executive Vice President, SKM, Inc., Austin, Texas, March 25, 1976 to July 9, 1976.

Consultation on Photon Tomography, Energy Conservation Systems, Balcones Research Center, Austin, Texas.

Summary continued

Executive Vice President and Director of Research and Development, Scientific Measurement Systems, Inc. (formerly SKM, Inc.), July 9, 1976 to September 8, 1980.

President and Director of Research and Development, Scientific Measurement Systems, Inc., September 8, 1980---

Academic Affiliation

The University of Texas at Austin, Graduate Research Council Appointment to Doctoral Committees.

Texas A&M University, Professor of Graduate School of Engineering, Visiting Lecturer.

Publications

Over 100 publications in scientific journals.

Recent Publications:

Examination of Concrete by Computerized Tomography by I. L. Morgan, H. Ellinger, R. Klinksiek, and J. Neils Thompson, Journal of the American Concrete Institute, No. 1, Proceedings V. 77, January-February 1980.

Tomographic Analysis of Structural Materials, by H. Ellinger, I. L. Morgan, R. Klinksiek, F. Hopkins and J. Neils Thompson, Proceedings of the Society of Photo-Optical Instrumentation Engineers, Volume 182, April 19-20, 1979, Washington, D. C.

Examination of Steel and Concrete by Computerized Tomography, by I. L. Morgan, H. Ellinger, R. Klinksiek, and J. Neils Thompson, Reprint, RILEM, Volume 2, June, 1979, Stockholm, Sweden.

Examination of Power Poles by Computerized Tomography by James A. Taylor, I. L. Morgan and Hunter Ellinger, The International Research Group on Wood Preservation, Working Group II, Fundamentals of Testing, Sub-group 5, Non-destructive testing for the detection of defects in poles, August 25, 1980.

Industrial Tomography Applications by Forrest F. Hopkins, Ira L. Morgan, Hunter D. Ellinter, Rudy V. Klinksiek, Glenn A. Meyer and J. Neils Thompson, paper given at the Sixth Conference on the Application of Accelerators in Research and Industry, November 3-5, 1980, Denton, Texas (to be published).

Patents

Helium-3 Neutron Counter
Method for Pulsing High Voltage Accelerators
Nuclear Borehole Analyzer
X-ray Tomography
Industrial X-ray Tomography

Additional patent applications will be supplied on request.

IEEE Transactions on Nuclear Science, Vol. NS-28, No. 2, April 1981

INDUSTRIAL TOMOGRAPHY APPLICATIONS *

Forrest F. Hopkins, Ira L. Morgan, Hunter D. Ellinger,
Rudy V. Klinksiek, Glenn A. Meyer and J. Neils Thompson

Scientific Measurement Systems, Inc.
Austin, Texas

Summary

The technique of computerized photon tomography has been applied in the nondestructive evaluation of a number of inanimate objects.[1,2,3] Hardware and software capabilities for industrial tomographic analysis, particularly of high-density objects, have been developed. Spatial resolution is on the order of 1-2mm for density variations of a few percent.

TOMOGRAPHIC SYSTEM AND OPERATION

Sources

The conventional photon sources utilized in medical tomography, x-ray tubes with average photon energy output of 40-60 keV, are inadequate for scanning dense objects due to prohibitively low transmission rates. Scientific Measurement Systems, Inc. has incorporated into its tomographic system isotopic sources which emit higher energy γ rays. Specifically, 1.6 Curie ^{137}Cs with a single line at 662 keV and a 200 Curie ^{192}Ir source, which emits lines or clusters of lines with energies (strengths) of 310 keV (68%), 468 keV (23%) and 610 keV (8%), have been used with good success for objects with total densities as low as 1 gm/cm^2 and as high as 70 gm/cm^2. Commonly available specific activities are approximately 0.1 Curie/mm^3 for ^{137}Cs (halflife of 30 years) and 15 Curies/mm^3 for ^{192}Ir (74-day halflife), so the ^{192}Ir is preferable in most situations.

Detectors

The detection of the high-energy photons emitted by isotopic sources, or alternatively electron accelerators, requires modifications in the technology used in medical tomography. Scanning of high-mass objects, particularly with isotopes, can lead to very low transmission rates and hence often requires a very good signal-to-noise ratio (SNR). Rather than using current integration as in the medical units, SMS has developed a fast plastic scintillator system[a] which is operated in the photon counting mode. Pulse counting up to rates of 20 megahertz is feasible. The detectors are very inexpensive and even with low performance phototubes exhibit dark count rates as low as 100/sec. or less. The demonstrated dynamic range of 10^4-10^5 is convenient for scanning very dense objects through which flux transmission can vary by several orders of magnitude. Such a detector of $\sim$ 200mm length has been measured to be $\sim$ 80% efficient for the 662 keV line.

Scanner Geometry/Collimation

In analogy to third generation, rotate-only fan beam geometry of the medical scanning configurations, the object table in the SMS industrial tomograph is rotated to provide the various angular views while source and detector bank, separated by 122cm, are held fixed. The detector bank consists of 31 plastic scintillators, each 6.4mm by 20mm in cross-sectional dimensions and of varying lengths, with a spacing of 14.2mm center to center. The bank is stepped over a small interval to increase the density of the rays in the fan. The detectors are fronted by a lead collimator with apertures 2.4mm in width and 2.0mm in height. The ^{192}Ir and ^{137}Cs sources are also provided with collimation and shielding, to define as closely as possible only that part of the flux which intercepts the active regions of the detectors.

Scattering/Beam Hardening

Two phenomena which require attention in the scanning of dense objects with high-energy photons are scattering and beam hardening. The former is important due to the fact that Compton scattering is the predominant attenuation process at photon energies above 300 keV in media with atomic number 30 or less. Photons scattered directly from the object or from neighboring detectors or structural material can enter a detector, causing an excess of counts and an apparent depression in the magnitude of the mass viewed. Computer simulation is used to assess scattering effects for particular configurations. Corrections for scattering based on empirical measurements are made to the transmission data taken with the SMS tomograph.

Beam hardening, the alteration of the source energy spectrum as it penetrates an object due to preferential attenuation of the lower energy photons, also leads to an underestimation of mass. Where composition of the object is known, the mass versus transmission relationship is either calculated or measured using a set of uniform step wedges of the appropriate material. Even using a high-energy isotopic source, such as ^{192}Ir, can lead to errors of a few percent in measured opacities (densities) due to hardening.

Reconstruction Algorithms

Scientific Measurement Systems, Inc. has developed an extensive reconstruction system for obtaining two-dimensional cross-sectional density maps, tomograms, from the projection data. It includes options to use a variety of filtering, interpolation and back projection methods, as well as two-dimensional FFT techniques and a variety of iterative techniques. The usual approach is the analytic method of filtered back projection in fan beam geometry.

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* Supported in part by SMS, Inc., the Dept. of Defense, the Dept. of Transportation, and REA

[a] Patented

0018-9499/81/0400-1717$00.75©1981 IEEE

Tomograms

Tomograms of objects of several different compositions which have been scanned with the SMS tomograph are presented in Figures 1-7. The gray scale in the tomograms corresponds to increasing opacity, which for these cases is essentially directly proportional to density. Specifically white is high density and black is low density. The ranges of the gray scales of the tomograms are represented in units of g/cm^3.

Plastic

Tomograms of a fibrous polypropylene cartridge filter are shown in Figure 1. The maximum mass encountered by the source flux in this case was only about 0.5 gm/cm^2, resulting in a maximum attenuation of only 5% of the ^{192}Ir lines. The quality of the scan is remarkably good, given the slight attenuation of the high energy γ rays. The two-dimensional pixel matrix can be fitted to yield a radial density profile from the essentially cylindrically symmetric object, which is a direct indication of the quality of the filter.

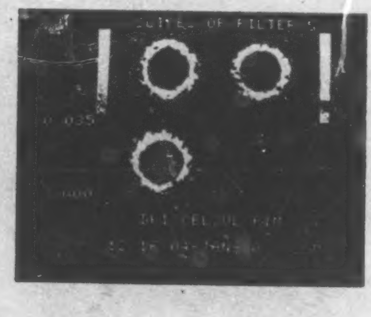

Figure 1. Three tomograms of a single, cylindrical polypropylene cartridge filter, each of which represents a slice at a particular point along the longitudinal axis. Outer diameter of the filter was about 3 inches and inner diameter was 1.5 inches.

Wood

The internal structure of wood is clearly revealed by tomographic analysis, including growth rings, knots, rot, worm damage, checks, and in certain cases moisture or preservative content. An example of a scan is shown in Figures 2 and 3 of the center section of a Douglas fir electric power pole. The spring and summer growth is distinct as is a large knot structure and various cracks and low density areas.

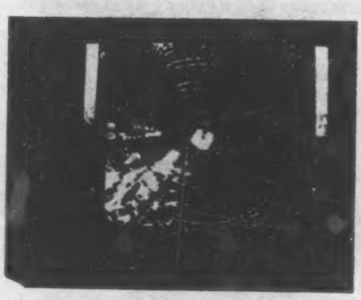

Figure 2. Tomogram of a central 8-inch by 8-inch region of a 17-inch diameter Douglas fir power pole.

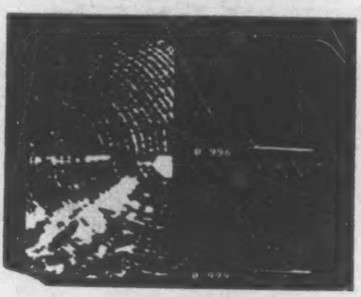

Figure 3. The upper right and lower left quadrants of the tomogram in Figure 2. For each quadrant a histogram is presented of the distribution of pixel values (density values), with a range (abscissa) of 0 to 1.3 gm/cm^3.

The density value distributions for two of the quadrants are shown in Figure 3. The first shows a distribution with a single large peak centered about 0.4 gm/cm^3 and some tailing toward zero, which corresponds to the large void in the picture. The second distribution exhibits a second peak centered at approximately 0.9 gm/cm^3, which corresponds to the knot density.

Concrete

Several features of concrete structures are visible in the tomograms presented in Figures 4-7. The aggregate in each case is discernible from the paste. Cracks and voids are evident, as is a centrally located steel reinforcement rebar in Figure 4.

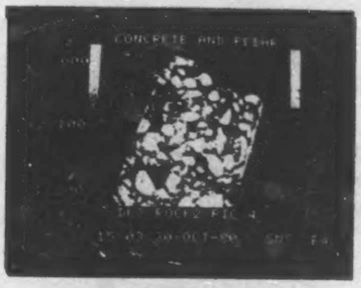

Figure 4. Tomogram of a piece of structural concrete Note the crack extending from the rebar (bright object in the center) to the surface. Densities of the aggregate are roughly 2.6 gm/cm^3 and of the paste about 2.0 gm/cm^3.

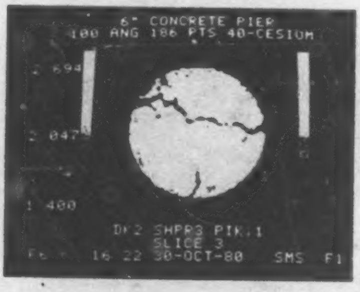

Figure 5. Tomogram of a 6-inch diameter concrete cylinder intentionally loaded to failure. Cracks estimated to be as small as a few hundred microns and as large as one or more millimeters are visible.

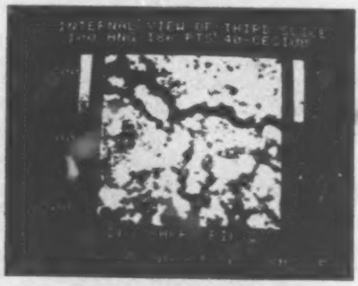

Figure 6. A magnification of the central region of Figure 5, emphasizing the major interior crack and a sizeable void (to the left of the center).

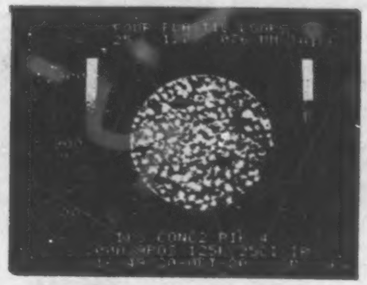

Figure 7. Tomogram of a 6-inch diameter concrete cylinder in which loops of plastic (acetate and polyvinyl) were placed, one in each quadrant of the cylinder, with thicknesses in the slice plane. The thicknesses of the loops, starting with the upper right quadrant and proceeding counterclockwise, were 0.030 inch (762 microns), 0.010 inch (254 microns), 0.005 inch (127 microns), and 0.003 inch (76 microns). The first three loops are clearly present, and the fourth is less distinct but still noticeable.

The results with the phantom presented in Figure 7 imply that cracks down to ~ 75 microns and less in concrete piers should be detectable with photon tomography.

Steel

Figure 8 presents a scan through a steel butt weld which was fabricated with a substantial defect. The tomographic imaging of the defect yields dimensional information which is not provided by radiography.

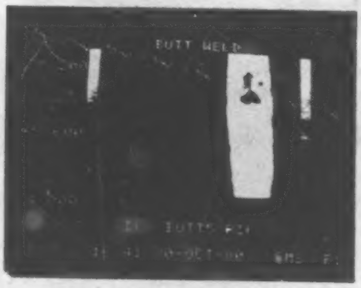

Figure 8. Tomogram of a steel butt weld of plates of cross-sectional dimensions 9cm by 2.3cm. Density anomalies above center constitute welding flaws.

Electronic Components

A high resolution series of scans has been taken of a dosimeter module of a type used in the Skylab experiment. The dosimeter consists of a spherical ionization chamber and a housing containing electronics, as can be seen in Figure 9. The tomogram shown was produced with ~ 2.5mm resolution, which was sufficient to provide a three-dimensional matrix of density values. The matrix is appropriate for use with radiation transport codes to provide estimates of radiation damage to key electronic components.

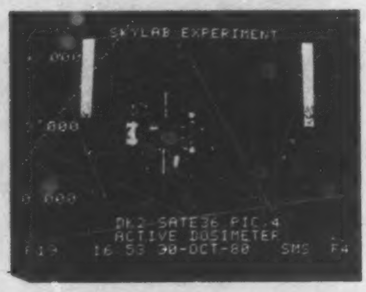

Figure 9. Tomogram of a Skylab dosimeter module, with cross-sectional dimensions of about 8 inches by 6 inches. Note the ionization chamber (circle) to the right and electronics to the left.

References

1. H. Ellinger, I. L. Morgan, R. Klinksiek, Forrest Hopkins, and J. N. Thompson, "Tomographic Analysis of Structural Materials," Proceedings of the Society of Photo-Optical Instrumentation Engineers, V. 182, 179 (1979).

2. I. L. Morgan, H. Ellinger, R. Klinksiek, and J. N. Thompson, "Examination of Concrete by Computerized Tomography," American Concrete Institute Journal, Proceedings, V. 77, 23 (1980).

3. I. L. Morgan, Forrest Hopkins, H. Ellinger, R. Klinksiek, Glenn Meyer and J. N. Thompson, "Nondestructive Evaluation by Computerized Photon Tomography," Paper Summaries, National Conference, American Society for Non-destructive Testing, October 6-9, 1980, Houston, Texas, p. 212.

100 Series Laboratory Tomograph

The SMS 100 Series Tomograph is a small system designed for scientific laboratory applications where high resolution is required and where speed is not critical. Using an x-ray source with a single detector and an eight bit microcomputer, this system can produce a tomogram of an object up to 29 pounds on a Polaroid print in 60 to 80 minutes.

Features

- *Turntable/track object carrier permits an object to be placed in any position.*
- *A 70 KV x-ray tube source, a reliable, yet low radiation, easily shielded photon source.*
- *Single collimated detector reduces the effects of scattering, permits the use of high quality photomultiplier detector tubes without excessive cost, and permits source-detector spacing adjustment to suit object diameter, choice of integrator for very fast scans or counter for very opaque objects.*
- *A medium sized eight bit microcomputer with disk drive and printer provides economical computing power for the slower scan speeds.*
- *Polaroid photographic display produces good quality prints.*

Options

- *Automatic vertical object carrier motion to permit automatic slice plane advance or use as a digital radiograph.*
- *CRT display with 256x256 resolution and 16 level gray scale.*
- *^{192}Ir isotopic source for scanning high opacity objects.*

200 Series General Purpose Tomograph

The SMS 200 Series Tomograph is a full capability system suitable for test laboratory and general production line applications.

Fast scanning of dense objects up to 200 pounds in routine testing is made possible by the use of isotopic photon sources, multi-element detector array, and a minicomputer with a separate array processor for high speed numeric calculations. The 200 series produces a tomogram in 5 to 10 minutes.

Features

- *Turntable/track object carrier permits an object to be placed in any position.*
- ^{192}*Ir or* ^{60}*Co source provides sufficient photon energy for most laboratory applications.*
- *A 32 element detector array speeds the photon detection process.*
- *Plastic scintillating photon counters provide economic detectors for large arrays.*
- *DEC PDP-11 with separate array processor provides the computing power needed for high speed picture processing.*
- *A 256 x 256 CRT display with 16 level gray scale provides excellent resolution for tomograms.*

Options

- *Automatic vertical object carrier motion permits taking of vertical projections or three dimensional examination.*
- *A 64 element or larger detector array provides faster scanning.*
- *A 512 x 512 or greater CRT display provides extremely high display resolution.*
- *Circular geometry gantry-type system permits use in general production line applications.*

300 Series Industrial Tomographs

The SMS 300 Series Tomographs are full capability, high performance systems suitable for production line use. Each system in the 300 Series is customized for a particular application. Speed will vary depending upon configuration and object parameters of interest. The highest operational speeds are obtained through the use of extra array memory and by optimization of the scan assembly mechanical construction to provide continuous feed of the scanned object and reduce mechanical motion time.

Features

- *Scan assembly includes customized object handling system integrated with an optimized source/detector geometry, providing the highest available scan speeds. Most systems will feature some variation of the circular geometry gantry-type scan assembly, which is best for continuous scanning.*
- *Photon source chosen for suitability for particular scan applications. ^{192}Ir, ^{60}Co, x-ray tube, or linear accelerators are available.*
- *32-256 element detector arrays provide fast photon detection.*
- *Plastic scintillating photon counters provide economic detectors for large arrays.*
- *DEC PDP-11 with separate array processor having large memory complement provides the computing power needed for highest available picture processing speeds.*
- *A 256x256 CRT display with 16 level gray scale provides excellent resolution for tomograms.*

Options

- *Turntable/track object carrier with automatic vertical motion permits taking of vertical projections or three dimensional examination in applications where continuous scanning of a production line is not required.*
- *A 64 element or larger detector array provides even faster scanning.*
- *A 512x512 or greater CRT display provides extremely high display resolution.*
- *Color display provides easy recognition by operational personnel of conditions of interest in the object being scanned.*

SCIENTIFIC MEASUREMENT SYSTEMS, INC.

Tomographic Scanning Services

Scientific Measurement Systems, Inc., maintains a fully equipped laboratory to perform tomographic scanning services for customers who do not wish to purchase a system or who are interested in demonstration scans.

Service Rates

Single items: $150 per hour, 4-hour minimum

Items in volume: $Per item charge quoted upon request.

Price Quotation

The total time required to scan an object and produce a tomogram depends upon a number of factors, including the density of the material, the size of the object, the density and size of the defect or feature to be detected, and the number of scans desired. Price quotations can be made only after a discussion of these factors with an SMS scanning program manager.

Scan Program Planning

SMS program managers will work with customer representatives to outline a scan program plan that will meet the customer's needs. For initial scans of new types of objects, the customer may not know in advance the types and number of scans he needs. In such cases the customer is welcome to send a representative to the SMS scanning laboratory to assist in planning the scan program, monitoring the results, and authorizing necessary changes. Once scanning procedures have established to the customer's satisfaction, the authorized program plan will be kept on file and future scans can be performed without requiring the representative's presence.

SYSTEM MAINTENANCE SERVICES

Scientific Measurement Systems, Inc. provides full system maintenance services for its sales and lease computerized tomograph systems.

Installation and Initial Maintenance

Scientific Measurement Systems' sales prices include the cost of installation, except for special environmental packaging and process interface equipment to be supplied by the customer. For a period of 90 days after the date of acceptance of an installed system, SMS will provide any necessary parts and maintenance required to keep the system in top operating condition.

Maintenance Contract

Scientific Measurement Systems offers a maintenance contract under which it supplies all parts and labor for system maintenance for the single yearly charge of 10% of the system sales price.

Callout Maintenance

Scientific Measurement Systems also fully supports its sales systems on a callout basis. The customer is charged the cost of parts, labor and transportation from the nearest SMS service facility.

Lease System Maintenance

The full cost of maintenance of lease systems is covered by the lease charge.

Customer Training

Scientific Measurement Systems will train customer personnel in the routine testing and maintenance of sales and lease systems. Quotations are available upon request.

PERFORMANCE SPECIFICATIONS

(Preliminary)

Specification	100 Series	200 Series	300 Series
Maximum object diameter	any diameter	36 inches*	optional
Maximum opacity equivalents (water)	12 inches	50 inches	100 inches
Maximum opacity equivalents (steel)	1/2 inch	6 inches	12 inches
Maximum object weight (lbs)	20	200*	-
Translational speed (inches/second)	0-10	0-5*	0-10
Rotational time (seconds/degree)	.01	.02	down to :001
Vertical speed (inches/second)	.5	.2	up to 60
Aperture size (inches)	.010-.25	.040-.25	.010-1.0
Data acquisition times-			
minimum (seconds/scan)	100	20	0.2
typical (seconds/scan)	1,000	300	20
Picture computation time			
typical (minutes/picture)**	60	5	0.1-1.0
Total time for tomogram			
minimum (minutes)	62	5.3	0.1
typical (minutes)	77	10	1.4

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* Standard--may be modified

** For moderate resolution pictures

CONTRACT R&D SERVICES

Scientific Measurement Systems, Inc. offers contract R&D services in the area of Tomography for topics such as:

- *feasibility studies of Computerized Industrial Tomography for particular applications*
- *development of advanced tomographic techniques*
- *studies of physical phenomena in which Tomography is a useful research tool*
- *studies of the effectiveness of a customer's existing quality control techniques.*

Scientific Measurement Systems, Inc. personnel have extensive experience in performing research in both the academic and corporate arenas for both government and industry. Skills available at SMS include nuclear physics, materials sciences, mathematics, computer sciences, mechanical engineering, and electrical engineering.

Representative contract research programs performed to date by SMS include:

- *earthquake damage assessment by backscatter tomography*
- *improving the spatial resolution of computerized tomography.*
- *design and construction of a unique medical tomograph*
- *tomographic scanning of fibrous filter cartridges and development of a computer model for their analysis*
- *design and testing of an energy conservation coulometric cell based watthour meter*
- *tomographic analysis of electric power poles*

- *feasibility study for tomographic examination of satellites*
- *development of improved tomographic detectors*
- *tomographic analysis of bridge weldments and concrete*
- *tomographic analysis of solid-propellant rockets*
- *study of applicability of tomography to examination of treated power poles to determine extent of treating chemical impregnation*
- *examination of steel tubing for size, wall thickness and eccentricity*
- *examination of steel bars for delamination defects*
- *examination of turbine blades and aircraft panels for defects*
- *examination of statues and art objects*
- *underwater examination of piers*
- *examination of nuclear fuel rods and waste barrels.*

SMS program managers will be happy to discuss your research and development needs and provide you with a prompt quotation based upon a mutually agreed program plan.

SCIENTIFIC MEASUREMENT SYSTEMS, INC.

Tomographic Application Note

Examination of Metal Objects

The industrial tomographic systems built by Scientific Measurement Systems, Inc. can be used to make cross-sectional density maps of a wide variety of metal objects. Objects with up to ten inches of steel have been successfully examined, as have I-beams and reinforcement steel in concrete, pipe with wall thicknesses up to 1.25 inches, turbine blades, and a variety of welds.

The photon sources used for most applications are one of the two radioisotopes commonly used in industrial radiography: Iridium-192 and Cobalt-60. Iridium is cheaper and easier to shield, while cobalt is almost twice as penetrating and is thus more appropriate for very dense objects.

The low transmissions typical of at least some of the paths in most metal objects requires a detector capable of measuring very low beam intensities. The patented SMS detector system (U. S. Patent No. 4,284,895) counts each individual gamma-ray transmitted through the object at rates from 10 per second to 30 million per second. Unlike film or floroscopic screens, the SMS detector systems are quite efficient at high gamma-ray energies and respond almost exclusively to the directly transmitted gamma-rays (60% - 90% of direct transmission is detected, with the contribution from object scatter usually less than 1% of this value).

Iridium gamma rays have an average energy of 390 keV, which means that about half of them are scattered or absorbed by each 0.4 inches of steel. Since signals as small as .001% can be usefully measured by SMS detectors, steel thicknesses of more than 5 inches can be examined with iridium sources. For routine examination of greater than 4 inches of steel, however, it is often preferable to use cobalt sources, which emit gamma rays of higher energy (about 1.25 MeV) which can be used for examining up to 10 inches of steel.

The shape and size of the metallic object have some effect on the feasibility of scanning. The preferred shape is one that permits the object or the tomograph to be rotated 360°. As long as the total metal thickness along any line in the slice plane is not too great, the overall size of the cross-section can be up to several feet in diameter. The object can be as long as desired in the direction perpendicular to the cross-section. In certain cases, special computer programs can generate the information needed by the user from data taken under conditions that don't meet these restrictions.

The typical resolution of industrial tomographic systems is about .050", and cracks or holes can often be seen down to .003". The density resolution is a function of the exposure time $[\sigma(p) \propto 1/\sqrt{T}]$ and is typically a few percent for areas of a few tenths of an inch on a side. For larger areas, the resolution is even better $[\sigma(p) \propto s^{-3/2}]$.

DEPARTMENT OF HEALTH & HUMAN SERVICES
Office of the Secretary
Washington, D.C. 20201

MAY 25 1982

The Honorable Parren J. Mitchell
Chairman, Small Business Committee
U.S. House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

We are submitting a statement for the record for your May 4 hearing on the "Small Business Innovation Development Act," H.R. 4326. We understand that issues affecting this Department were raised at the hearing. The enclosed statement addresses those issues. My staff has discussed the submission of this statement with your Committee staff.

Thank you for the opportunity to outline the Department's activities in this area. I hope this information is helpful to your Committee's deliberations.

Sincerely yours,

Thomas R. Donnelly, Jr.
Assistant Secretary for Legislation

Enclosure

STATEMENT FOR THE RECORD

SUBMITTED BY THE

DEPARTMENT OF HEALTH AND HUMAN SERVICES

ISSUES RAISED AT THE HEARING AND NIH RESPONSE

- The total number of small, life science, high technology firms exceeds 3,500.

  Response: In testimony before Congress we expressed concern that our experience in attempting to identify small businesses through our "sources sought" announcements and conferences indicates a relative paucity of small businesses which possess biomedical research capabilities, especially in the basic science area. Eighty-eight small businesses were active as NIH contractors in FY 1981, and about 100 additional ones have reached the central NIH source list as the result of small business conferences, solicitations, direct contacts and other mechanisms. Additional small firms have contacted NIH in the past but have failed either to compete successfully for funding or to convince program officials that their proposals are relevant to NIH needs.

  The National Science Foundation has had a similar experience in its grants program. Out of a total of 27,581 applications submitted between FY 1977 and FY 1981 to the life sciences division, only 78 came from for-profits and eight of these came from small businesses. Further, of the 11,292 awards, only 26 went to for-profit organizations.

  According to Dr. J. Leslie Glick, President and Chief Executive Officer of Genex Corporation, at the end of 1981 there were around 110 young firms specializing in recombinant DNA technology, comprising a total capitalization of nearly $700 million. In addition to these small firms, about 120 large companies worldwide are engaged in this area.

- NIH has requested exemption from the set-aside requirement.

  Response: In testimony before Congress the Department expressed support of the passage of S. 881 and indicated that it is prepared to increase the current efforts to involve small businesses in our programs. We stated that, should S. 881 become law, we would make every attempt to meet the one percent set-aside requirement stipulated in the bill in order to make the Small Business Innovation Research Program a success. While the Administration has opposed the higher three percent set-aside in H.R. 4326, neither the Administration nor HHS has requested that NIH or any other agency be exempted from these bills.

- NIH has concluded that, "Small firms cannot perform the same quality of basic research as universities and other nonprofit institutions."

  Response: The Department has never opposed H.R. 4326 by questioning the quality of research conducted by small firms. Instead, in testimony before the House Small Business Committee, we testified that there are only a limited number of small busineses which possess biomedical research capabilities. Therefore, we expressed serious reservations about the magnitude of the set-aside. We explained that the private sector health research effort is concentrated in large firms, and often requires, such as in the area of drug development, an investment in the millions of dollars and highly specialized staff and facilities.

- NIH is inappropriately labeling as small business R&D such areas as the following:

    1. Repair, restore and rebind rare books.
    2. Provide a generator and other equipment for the National Library of Medicine.
    3. Catalog monographs in English and foreign languages.
    4. Remove existing elevated access flooring.

    Response: NIH does not characterize as R&D awards to small businesses the projects listed at the hearing. The awards cited are in-house service procurements and clearly come from a listing supplied by the Division of Administrative Services, NIH.*

    NIH has awarded to small businesses numerous R&D and R&D support contracts. NIH has utilized small businesses to perform biomedical evaluation studies and surveys, to conduct studies in virology, immunology, toxicology, and for animal production and the preparation of cell and tissue culture. Additionally, millions of dollars have been awarded to small businesses to establish and maintain rodent production centers. Other small businesses are providing support for the National High Blood Pressure Education Program. (See attached list.)

- Small businesses are not given the opportunity to perform the same quality of research as universities and other nonprofits. NIH, for twenty years, has prevented small life sciences firms from submitting research proposals "based on the false grounds that a sufficient number of small life sciences firms do not exist, and those that do exist are not able to perform quality research."

    Response: NIH has sought out small R&D firms through sources sought announcements in the Commerce Business Daily (CBD), by participating in meetings cosponsored by SBA and NSF, and by soliciting in the CBD and the NIH Guide for Grants and Contracts for sources and proposals for specific procurements. In addition, NIH encourages individual representatives of small businesses to contact staff in the Office of the Director or in the various individual NIH components.

    Grants became available to for-profit firms on January 4, 1982. NIH is advertising in the NIH Guide for Grants and Contracts, Science Magazine, and the CBD the fact that the grant system is now open to for-profits; it is also advertising in the NIH Guide and Science a request for nominations of scientists from the for-profit sector to serve on NIH study sections. It is anticipated that NIH will begin making appointments of for-profit scientists to study sections in the near future.

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*NIH has separated its procurement activities into two areas. The major NIH procurement activity, extramural R&D and R&D support, is coordinated by the Division of Contracts and Grants and the Office of Extramural Research and Training in the Office of the Director. The other area which is coordinated by the Division of Administrative Services, also in the Office of the Director, includes intramural service procurements (supplies, equipment services, etc.) and contracts for maintenance of the physical plant.

EXTENT OF NIH SUPPORT OF SMALL BUSINESSES

In FY 1980, NIH awarded $433,223,000 for R&D contracts. Of this amount, $32,502,000 was awarded to small businesses in open competitions. $4,895,000 more was awarded from set-asides for small and minority businesses. In FY 1981, although NIH awarded only $369,151,000 for R&D contracts, the amount allocated to small businesses remained above $30 million. $25,638,000 was awarded to small businesses in open competition, and the amount awarded from set-asides nearly doubled to $8,384,000. The NIH has awarded competitive R&D and R&D support contracts to small business firms in the following areas:

--Preparation of Bulk Chemicals and Drugs

--Development and Testing of a New Biodegradable Drug Delivery System

--Restoring and Refurbishing Infrared Heterodyne Radiometer

--Development of an Implantable Left Heart Assist System

--Electrical Energy Transmission Technique Development

--Comparison of Fluorides in Caries Prevention

--Resynthesis of Bulk Chemicals and Drugs

--Production of Clinical Doses of Anti-tumor Agents

--Follow-up and Toxicity Blood Determinations - LRC Patients

--Central Laboratory for Propranolol Heart Trial

--Services for Cancer Related Inquiries

--Establish Clinical Immunology Diagnostic Laboratory

--Virology, Immunology, Tissue Culture Support Service

--Cytogenetic Evaluation of High Risk Cancer Families

--Development of New Methods of Single Cell Separation

--Develop Progestagen Containing Microcapsules

--Measure Pulmonary Functions in Infants and Children

--National Clearinghouses (ex. Rheumatic Diseases)

--Support Services for Various Programs (like the DCRRC-NCI)

--Planning and Analytical Support Services

--Evaluation Studies

--Synthesis of Various Phosphoramides

--Laboratory Mouse Breeding Facility

--Production of RNA Avian Oncogenic Viruses

--Evaluation of Electrode Materials

--Support the Gastrointestinal Tumor Study Group

--Pathology Support for Carcinogenesis Testing Program

--Processing Cultured Tissues and Cells

--Examine Embryonic Kidney Nephroblastomas

--Production of Lipopolysaccharides (Endotoxins)

--Primary Genetic Center for Germfree Rodents

--Production of Aged Rats

--Carcinogenicity and Toxicity Study in Laboratory Animals

--Study of the Marek's Disease Herpes Virus

--Produce Avian Leucosis Viruses

--Prepare Desoctapeptide Insulin and Chicken Insulin

I

Union Calendar No. 279

97TH CONGRESS
2D SESSION

H. R. 4326

[Report No. 97–349, Parts I, II, III, IV, V, VI, and VII]

To amend the Small Business Act to strengthen the role of the small, innovative firms in federally funded research and development, and to utilize Federal research and development as a base for technological innovation to meet agency needs and to contribute to the growth and strength of the Nation's economy.

IN THE HOUSE OF REPRESENTATIVES

JULY 29, 1981

Mr. LAFALCE introduced the following bill; which was referred to the Committee on Small Business

NOVEMBER 20, 1981

Additional sponsors: Mr. MITCHELL of Maryland, Mr. SMITH of Iowa, Mr. ADDABBO, Mr. GONZALEZ, Mr. BEDELL, Mr. RICHMOND, Mr. NOWAK, Mr. LUKEN, Mr. IRELAND, Mr. SKELTON, Mr. EVANS of Georgia, Mr. STENHOLM, Mr. MAZZOLI, Mr. MAVROULES, Mr. CROCKETT, Mr. HATCHER, Mr. WYDEN, Mr. ECKART, Mr. DORGAN of North Dakota, Mr. SAVAGE, Mr. ROEMER, Mr. FARY, Mr. MCDADE, Mr. CONTE, Mr. STANTON of Ohio, Mr. BROOMFIELD, Mr. MARRIOTT, Mr. WILLIAMS of Ohio, Mrs. SNOWE, Mr. DANIEL B. CRANE, Mr. HILER, Mr. STATON of West Virginia, Mr. WEBER of Minnesota, Mr. DAUB, Mr. SMITH of New Jersey, Mr. WEBER of Ohio, Mr. DREIER, Mr. MOLINARI, Mr. SILJANDER, Mr. AKAKA, Mr. ATKINSON, Mr. BARNARD, Mr. BARNES, Mr. BEVILL, Mr. BONKER, Mr. BOWEN, Mr. BROWN of Ohio, Mr. CLAY, Mr. CLINGER, Mr. COELHO, Mr. CORRADA, Mr. D'AMOURS, Mr. DASCHLE, Mr. DIXON, Mr. DUNN, Mr. DWYER, Mr. EDGAR, Mr. FAUNTROY, Ms. FERRARO, Mr. FISH, Mr. FOGLIETTA, Mr. FORD of Tennessee, Mr. FRANK, Mr. GEJDENSON, Mr. GINGRICH, Mr. GLICKMAN, Mr. GREEN, Mr. HANSEN of Utah, Mr. HORTON, Mr. HOYER, Mr. HUGHES, Mr. KILDEE, Mr. KOGOVSEK, Mr. LANTOS, Mr. LEACH of Iowa, Mr. LEWIS, Mr. LOWERY of California, Mr. LUNDINE, Mr. MCHUGH, Mr. MCKINNEY, Mr. MADIGAN, Mr. MARKEY, Mr. MARKS, Mr. MARTIN of New York, Mrs. MARTIN of Illinois, Mr. MICA, Ms. MIKULSKI, Mr. MONTGOMERY, Mr. MURPHY, Mr. NEAL, Mr. NELLIGAN, Mr. PATTERSON, Mr.

PORTER, Mr. PRITCHARD, Mr. RAHALL, Mr. RAILSBACK, Mr. RODINO, Mr. ROE, Mr. ROTH, Mr. SEIBERLING, Mr. SOLOMON, Mr. STANGELAND, Mr. SUNIA, Mr. VENTO, Mr. WEAVER, Mr. WILSON, Mr. WIRTH, Mr. WOLPE, Mr. WON PAT, Mr. WORTLEY, Mrs. COLLINS of Illinois, Mr. FAZIO, Mr. MITCHELL of New York, Mr. DYSON, Mr. STOKES, Mr. MYERS, and Mr. COATS

NOVEMBER 20, 1981

Reported with an amendment and referred to the Committee on Armed Services, to the Committee on Energy and Commerce and to the Committee on Science and Technology for a period ending not later than March 1, 1982, for consideration of such portions of the bill and amendment as fall within the jurisdiction of those committees under clause 1(c), 1(h), and 1(r), rule X respectively

[Strike out all after the enacting clause and insert the part printed in italic]

DECEMBER 8, 1981

Referred to the Committee on Veterans' Affairs for a period ending not later than March 1, 1982, for consideration of such portions of the bill and amendment as fall within the jurisdiction of that committee under clause 1(u), rule X

MARCH 1, 1982

Referral of H.R. 4326 to the Committees on Armed Services, Energy and Commerce, Science and Technology, and Veterans' Affairs extended for an additional period ending not later than March 2, 1982

MARCH 2, 1982

Referral of H.R. 4326 to the Committees on Armed Services, Energy and Commerce, Science and Technology, and Veterans' Affairs extended for an additional period ending not later than March 16, 1982; and H.R. 4326 sequentially referred to the Committee on Foreign Affairs and to the Permanent Select Committee on Intelligence for a period ending not later than March 16, 1982, for consideration of such portions of the bill and amendment as fall within the jurisdiction of those committees under clause 1(i), rule X and clause 2, rule XLVIII, respectively

MARCH 10, 1982

Reported from the Committee on Energy and Commerce, with an amendment

[Insert the part printed in lightface roman]

MARCH 16, 1982

Additional sponsors: Mr. FORSYTHE, Mrs. BOUQUARD, Mr. CONYERS, Mr. HAGEDORN, Mr. MCEWEN, Mr. OTTINGER, Mr. GREGG, Mr. WILLIAMS of Montana, Mr. ROBERTS of South Dakota, Mrs. SCHNEIDER, Mr. SIMON, Mr. BONER of Tennessee, Mr. WINN, Mr. BENJAMIN, Mr. BIAGGI, Mr. BAILEY of Pennsylvania, Mr. ANDREWS, Mr. BRODHEAD, Mr. STARK, Mr. JAMES K. COYNE, Mr. BRINKLEY, Mr. RITTER, Mr. ANTHONY, Mr. DICKS, Mr. DYMALLY, Mr. GINN, Mr. CLAUSEN, Mr. SMITH of Oregon, Mr. BROYHILL, Mr. ERDAHL, Mr. DOWNEY, Mr. MOORHEAD, Mr. CORCORAN, Mr. FASCELL, Mr. GUARINI, Mr. DE LA GARZA, Mr. GAYDOS, Mr. ALBOSTA, Mr. FIELDS, Mr. HALL of Ohio, Mr. DORNAN of California, Mr. LAGOMARSINO, Mr. DENARDIS, Mr. RATCHFORD, Mr. LEHMAN, Mr. HYDE, Mr. EMERY, Mr. JONES of Oklahoma, Mr. QUILLEN, Mr. JEFFORDS, Mr. FRENZEL, Mr. BURGENER, Mr. BEREUTER, Mr. MARLENEE, Mr. OBERSTAR, Mr. MURTHA, Mr. LEE, Mrs. CHISHOLM, Mr. RALPH M. HALL, Mr. WATKINS, Mr. RANGEL, Mr. SCHUMER, Mr. JENKINS, Mr. SMITH of Pennsylvania, Mr. WHITTAKER, Mr. PEPPER, Mr. JEFFRIES, Mr. VANDER JAGT, Mr. CHAPPELL, Mr. WOLF, Mr. OXLEY, AND Mr. FINDLEY

MARCH 16, 1982

Reported from the Committee on Veterans' Affairs, with amendments

[Insert the part printed in boldface italic]

MARCH 16, 1982

Reported from the Committee on Science and Technology, with an amendment

[Strike out all after the enacting clause and omit the part printed in italic and insert the part printed in boldface roman]

MARCH 16, 1982

Reported from the Committee on Foreign Affairs

MARCH 16, 1982

Reported from the Committee on Armed Services, with amendments

[Omit the part in brackets and insert the part printed in lightface italic]

MARCH 16, 1982

Reported from the Permanent Select Committee on Intelligence with an amendment, committed to the Committee of the Whole House on the State of the Union, and ordered to be printed

[Omit the part in struck through brackets and insert the part printed in roman]

A BILL

To amend the Small Business Act to strengthen the role of the small, innovative firms in federally funded research and development, and to utilize Federal research and development as a base for technological innovation to meet agency needs and to contribute to the growth and strength of the Nation's economy.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

~~SECTION 1. This Act may be cited as the "Small Business Innovation Development Act of 1981".~~

~~SEC. 2. (a) The Congress finds that—~~

~~(1) technological innovation creates jobs, increases productivity, competition, and economic growth, and is a valuable counterforce to inflation and the United States balance-of-payments deficit; and~~

~~(2) while small business is the principal source of significant innovations in the Nation, the vast majority of federally funded research and development is conducted by large businesses, universities, and Government laboratories.~~

~~(b) Therefore, the purposes of this Act are—~~

~~(1) to stimulate technological innovation;~~

~~(2) to use small businesses to meet Federal research and development needs; and~~

~~(3) to increase private sector commercialization of innovations derived from Federal research and development.~~

~~SEC. 3. Section 9(b) of the Small Business Act is amended—~~

~~(1) by striking out "and" at the end of clause (2);~~

~~(2) by striking out the period at the end of clause (3) and inserting in lieu thereof "; and"; and~~

~~(3) by adding at the end thereof the following:~~

~~"(4) to develop and maintain a source file and an information program to assure each qualified and interested small business concern the opportunity to participate in Federal agency small business innovation research programs;~~

~~"(5) to coordinate with participating agencies a schedule for release of SBIR solicitations, and to prepare a master release schedule so as to maximize small businesses opportunities to respond to solicitations;~~

~~"(6) to independently survey and monitor the operation of SBIR programs within participating Federal agencies; and~~

~~"(7) to report annually to the Committee on Small Business of the Senate and the Committee on Small Business of the House of Representatives on the SBIR programs of the Federal agencies and the Administration's information and monitoring efforts related to the SBIR programs.".~~

~~SEC. 4. Section 9 of the Small Business Act is amended by adding at the end thereof the following new subsections:~~

~~"(e) For the purpose of this section—~~

~~"(1) the term 'Federal agency' means an executive agency as defined in section 105 of title 5, United States Code, or a military department as defined in section 102 of such title;~~

~~"(2) the term 'funding agreement' means any contract, grant, or cooperative agreement entered into between any Federal agency and any small business for the performance of experimental, developmental, or research work funded in whole or in part by the Federal Government;~~

~~"(3) the term 'Small Business Innovation Research program' or 'SBIR' means a program under which a portion of a Federal agency's research or research and development effort is reserved for award to small business concerns through a simplified, standardized acquisition process having a first phase for determining, insofar as possible, the technical and economic feasibility of ideas proposed under the program, and a second phase, the awarding of which shall take into consideration the potential commercial applications of the research or research and development, to further develop the proposed idea to meet the particular agency needs; and a third phase where private capital pursues commercial applications of the research or research and development; phase three may also involve follow-on production contracts with some agencies for products or processes intended for use by the United States Government; and~~

~~“(4) the term ‘research’ or ‘research and development’ means any activity which is (A) a systematic study directed toward fuller scientific knowledge of the subject studied; (B) a systematic study directed specifically toward applying new scientific knowledge to meet a recognized need; or (C) a systematic application of new scientific knowledge toward production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements. Such term does not include studies related to the social sciences or the humanities.~~

~~“(f) Each Federal agency which has a research or research and development budget in excess of $100,000,000 for any fiscal year beginning with fiscal year 1982 shall expend not less than 1 per centum of such budget for fiscal year 1982, and not less than 2 per centum for all subsequent fiscal years with small business concerns specifically in connection with a small business innovation research program which meets the requirements of this Act and regulations issued hereunder. Funding agreements with small business concerns for research or research and development which result from competitive or single source selections other than under a small business innovation research program shall not~~

~~be counted as meeting any portion of the percentage requirements of this section.~~

~~"(g) Each Federal agency required by subsection (f) to establish a small business innovation research program shall in accordance with this Act and regulations issued hereunder—~~

~~"(1) establish an agency small business innovation research program;~~

~~"(2) determine categories of projects to be in its SBIR program;~~

~~"(3) issue small business innovation research solicitations in accordance with a schedule determined cooperatively with the Small Business Administration;~~

~~"(4) receive and evaluate proposals resulting from SBIR proposals;~~

~~"(5) select awardees for its SBIR funding agreements;~~

~~"(6) administer its own SBIR funding agreements (or delegate such administration to another agency);~~

~~"(7) make payments to recipients of SBIR funding agreements on the basis of progress toward or completion of the funding agreement requirements; and~~

~~"(8) make an annual report on the SBIR program to the Small Business Administration.~~

~~“(h) In addition to the requirements of subsection (f), each Federal agency which has a budget for research or research and development in excess of $20,000,000 for any fiscal year beginning with fiscal year 1982 shall establish goals specifically for funding agreements for research or research and development to small business concerns, and no goal established under this subsection shall be less in actual dollars than the amount of research or research and development awards made to small businesses in 1981.~~

~~“(i) Each Federal agency required by this section to have an SBIR program or to establish goals shall report annually to the Small Business Administration the number of awards pursuant to grants, contracts, or cooperative agreements over $10,000 in amount and the dollar value of all such awards, identifying SBIR awards and comparing the number and amount of such awards with awards to other than small business concerns.~~

~~“(j)(1) The Administrator of the Office of Federal Procurement Policy, in conjunction with the Small Business Administration, shall promulgate and issue appropriate regulations, in accordance with the provisions of subsections (f), (g), and (h) and within one hundred and twenty days after the date of enactment of the Small Business Innovation Research Act of 1981, for conduct of small business innovation re-~~

~~search programs within the Federal Government. Such regulations shall—~~

~~"(A) provide for simplified standardized and timely SBIR solicitations, proposals, and evaluation processes; and~~

~~"(B) require Federal agencies to coordinate SBIR solicitation release schedules with the Small Business Administration.~~

~~"(2) The National Science Foundation and the Small Business Administration shall furnish the Administrator of the Office of Federal Procurement Policy advice and assistance in the promulgation of regulations under this section.".~~

~~SEC. 5. The amendments made by this Act do not authorize the appropriation of funds.~~

SECTION 1. This Act may be cited as the "Small Business Innovation Development Act of 1981".

SEC. 2. (a) The Congress finds that—

(1) technological innovation creates jobs, increases productivity, competition, and economic growth, and is a valuable counterforce to inflation and the United States balance-of-payments deficit;

(2) while small business is the principal source of significant innovations in the Nation, the vast majority of federally funded research and development is con-

ducted by large businesses, universities, and Government laboratories; and

(3) small businesses are among the most cost-effective performers of research and development and are particularly capable of developing research and development results into new products.

(b) Therefore, the purposes of this Act are—

(1) to stimulate technological innovation;

(2) to use small businesses to meet Federal research and development needs; and

(3) to increase private sector commercialization innovations derived from Federal research and development.

SEC. 3. Section 9(b) of the Small Business Act is amended—

(1) by striking out "and" at the end of paragraph (2);

(2) by striking out the period at the end of paragraph (3) and inserting in lieu thereof "; and"; and

(3) by adding at the end thereof the following:

"(4) to develop and maintain a source file and an information program to assure each qualified and interested small business concern the opportunity to participate in Federal agency small business innovation research programs;

"(5) to coordinate with participating agencies a schedule for release of SBIR solicitations, and to prepare a master release schedule so as to maximize small businesses' opportunities to respond to solicitations;

"(6) to independently survey and monitor the operation of SBIR programs within participating Federal agencies; and

"(7) to report not less than annually to the Committee on Small Business of the Senate and the Committee on Small Business of the House of Representatives on the SBIR programs of the Federal agencies and the Administration's information and monitoring efforts related to the SBIR programs.".

SEC. 4. Section 9 of the Small Business Act is amended by adding at the end thereof the following new subsections:

"(e) For the purpose of this section—

Armed Services Committee amendment

Intelligence Committee amendment

[*"(1) the term 'Federal agency' means an executive agency as defined in section 105 of title 5, United States Code, or a military department as defined in section 102 of such title*~~[;]~~], except that it does not include any agency within the Intelligence Community (as the term is defined in section 3.4(f) of Executive Order 12333 or its successor orders);

"(1) the term 'Federal agency' means an executive agency as defined in section 105 of title 5, United States Code, other than the Department of Defense;

"(2) the term 'funding agreement' means any contract, grant, or cooperative agreement entered into between any Federal agency and any small business for the performance of experimental, developmental, or research work funded in whole or in part by the Federal Government;

"(3) the term 'Small Business Innovation Research Program' or 'SBIR' means a program under which a portion of a Federal agency's research or research and development effort is reserved for award to small business concerns through a uniform process having—

"(A) a first phase for determining, insofar as possible, the scientific and technical merit and feasibility of ideas submitted pursuant to SBIR program solicitations;

"(B) a second phase to further develop the proposed ideas to meet the particular program needs, the awarding of which shall take into consideration the scientific and technical merit and feasibility evidenced by the first phase and, where two or more proposals are evaluated as being of

approximately equal scientific and technical merit and feasibility, special consideration shall be given to those proposals that have demonstrated third phase, non-Federal capital commitments; and

"(C) where appropriate, a third phase in which non-Federal capital pursues commercial applications of the research or research and development and which may also involve follow-on production contracts with a Federal agency for products or processes intended for use by the United States Government; and

"(4) the term 'research' or 'research and development' means any activity which is (A) a systematic, intensive study directed toward greater knowledge or understanding of the subject studied; (B) a systematic study directed specifically toward applying new knowledge to meet a recognized need; or (C) a systematic application of knowledge toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements; but such term does not include (A) research or research and development conducted with funds appropriated to carry out the Public Health Service Act, the Compre-

Energy and Commerce Committee amendment

hensive Alcoholism and Alcohol Abuse Prevention, Treatment, and Rehabilitation Act of 1970, the Drug Abuse Prevention, Treatment and Rehabilitation Act, or titles V, XI, XVIII, and XIX of the Social Security Act, or (B) any other health-related research or research and development conducted by or through the Department of Health and Human Services or any of its entities.

"(f) (1)(1) Each Federal agency which has a research or research and development budget in excess of $100,000,000 for fiscal year 1982, or any fiscal year thereafter, shall expend not less than 0.5 per centum of such budget in fiscal year 1982 or in such subsequent fiscal year as the agency has such budget, not less than 1 per centum of such budget in the second fiscal year thereafter, not less than 2 per centum of such budget in the third fiscal year thereafter, and not less than 3 per centum of such budget in all subsequent fiscal years with small business concerns specifically in connection with a small business innovation research program which meets the requirements of the Small Business Innovation Development Act of 1981 and regulations issued thereunder. Funding agreements with small business concerns for research or research and development which result from competitive or single source selections other than under a small business innovation research program shall not be

counted as meeting any portion of the percentage requirements of this section.

Veterans' Affairs Committee amendment

"(2) In determining the amount of a Federal agency's research or research and development budget for any fiscal year for the purposes of paragraph (1), expenditures by the agency for research or research and development activities conducted by employees of the agency in or through Government-owned, Government-operated facilities shall be excluded.

Armed Services Committee amendment

"(2) Amounts appropriated for atomic energy defense programs of the Department of Energy shall for the purposes of paragraph (1) be excluded from the amount of research or research and development budget of that Department.

"(g) Each Federal agency required by subsection (f) to establish a small business innovation research program shall, in accordance with this Act and regulations issued hereunder—

"(1) unilaterally determine categories of projects to be in its SBIR program;

"(2) issue small business innovation research solicitations in accordance with a schedule determined cooperatively with the Small Business Administration;

"(3) unilaterally receive and evaluate proposals resulting from SBIR proposals;

"(4) unilaterally select awardees for its SBIR funding agreements;

"(5) administer its own SBIR funding agreements (or delegate such administration to another agency);

"(6) make payments to recipients of SBIR funding agreements on the basis of progress toward or completion of the funding agreement requirements; and

"(7) make an annual report on the SBIR program to the Small Business Administration and the Office of Science and Technology Policy.

"(h) In addition to the requirements of subsection (f), each Federal agency which has a budget for research or research and development in excess of $20,000,000 for any fiscal year beginning with fiscal year 1982 or subsequent fiscal year shall establish goals specifically for funding agreements for research or research and development to small business concerns, and no goal established under this subsection shall be less than the percentage of the agency's research or research and development budget expended under funding agreements with small business concerns in the immediately preceding fiscal year.

"(i) Each Federal agency required by this section to have an SBIR program or to establish goals shall report annually to the Small Business Administration the number

of awards pursuant to grants, contracts, or cooperative agreements over $10,000 in amount and the dollar value of all such awards, identifying SBIR awards and comparing the number and amount of such awards with awards to other than small business concerns.

"(j) The Small Business Administration, after consultation with the Administrator of the Office of Federal Procurement Policy, the Director of the Office of Science and Technology Policy, and the Intergovernmental Affairs Division of the Office of Management and Budget, shall, within one hundred and twenty days of the enactment of the Small Business Innovation Development Act of 1981, issue policy directives for the general conduct of the SBIR programs within the Federal Government, including providing for—

"(1) simplified, standardized, and timely SBIR solicitations;

"(2) a simplified, standardized funding process which provides for (A) the timely receipt and review of proposals; (B) outside peer review for at least phase two proposals; (C) protection of proprietary information provided in proposals; (D) selection of awardees; (E) retention of rights in data generated in the performance of the contract by the small business concern; (F) transfer of title to property provided by the agency to the small business concern if such a transfer would

be more cost effective than recovery of the property by the agency; (G) cost sharing; and (H) cost principles and payment schedules;

"(3) exemptions from the regulations under paragraph (2) if national security or intelligence functions clearly would be jeopardized;

"(4) minimizing regulatory burden associated with participation in the SBIR program for the small business concern which will stimulate the cost-effective conduct of Federal research and development and the likelihood of commercialization of the results of research and development conducted under the SBIR program; and

"(5) simplified, standardized, and timely annual report on the SBIR program to the Small Business Administration and the Office of Science and Technology Policy.

"(k) The Director of the Office of Science and Technology Policy, in consultation with the Federal Coordinating Council for Science, Engineering and Research, shall, in addition to such other responsibilities imposed upon him by the Small Business Innovation Development Act of 1981—

"(1) independently survey and monitor all phases of the implementation and operation of SBIR pro-

grams within agencies required to establish an SBIR program, including compliance with the expenditures of funds according to the requirements of subsection (f) of this section; and

"(2) report not less than annually, and at such other times as the Director may deem appropriate, to the Committees on Small Business of the Senate and the House of Representatives on all phases of the implementation and operation of SBIR programs within agencies required to establish an SBIR program, together with such recommendations as the Director may deem appropriate.".

Science and Technology Committee amendment

SECTION 1. This Act may be cited as the "Small Business Innovation Development Act".

SEC. 2. (a) The Congress finds that—

(1) technological innovation creates jobs, increases productivity, competition, and economic growth, and is a valuable counterforce to inflation and the United States balance-of-payments deficit;

(2) while small business is a principal source of significant innovations in the Nation, the majority of federally funded research and development is conducted by large

businesses, universities, and Government laboratories; and

(3) small businesses are among the most cost-effective performers of research and development and are particularly capable of developing research and development results into new products.

(b) Therefore, the purposes of this Act are—

(1) to stimulate technological innovation;

(2) to encourage the greater utilization of small business to meet Federal research and development needs; and

(3) to increase private sector commercialization of innovations derived from Federal research and development.

SEC. 3. Section 9(b) of the Small Business Act is amended—

(1) by striking out "and" at the end of paragraph (2);

(2) by striking out the period at the end of paragraph (3) and inserting in lieu thereof a semicolon; and

(3) by adding at the end thereof the following:

"(4) to develop and maintain a source file and an information program to assure each qualified and interested small business concern the opportunity to participate in Federal agency small business innovation research programs;

"(5) to coordinate with participating agencies a schedule for release of SBIR solicitations, and to prepare a master release schedule so as to maximize small businesses' opportunities to respond to solicitations;

"(6) to report annually to the Office of Science and Technology Policy on the SBIR program responsibilities assigned to it under this Act; and

"(7) to report not less than annually to the Senate and the House of Representatives on the SBIR programs of the Federal agencies and the Administration's responsibilities related to the SBIR programs.".

SEC. 4. Section 9 of the Small Business Act is amended by adding at the end thereof the following new subsections:

"(e) For the purpose of this section—

"(1) the term 'Federal agency' means an executive agency as defined in section 105 of title 5, United States Code, or a military department as defined in section 102 of such title;

"(2) the term 'funding agreement' means any contract, grant, or cooperative agreement entered into between any Federal agency and any small business for the performance of experimental, developmental, or research work funded in whole or in part by the Federal Government;

"(3) the term 'small business innovation research program' or 'SBIR program' means a competitive program designed to involve small businesses in meeting Federal research and development objectives and to promote innovation through a uniform process having—

"(A) a first phase for determining, insofar as possible, the scientific and technical merit and feasibility of proposals submitted pursuant to SBIR program solicitations;

"(B) a second phase to further develop the proposals to meet the particular program needs, the awarding of which shall take into consideration the scientific and technical merit and feasibility evidenced by the first phase and, if two or more proposals are evaluated as being of approximately equal scientific and technical merit and feasibility, special consideration shall be given to those proposals that have demonstrated third phase, private capital commitments; and

"(C) when appropriate, a third phase in which commercial applications of the research or research and development are pursued with private capital or in which contracts are made with a Federal agency for products or processes intended to benefit the United States Government; and

"(4) the term 'research' or 'research and development' means any activity which is (A) a systematic, intensive study directed toward greater knowledge or understanding of the subject studied; (B) a systematic study directed specifically toward applying new knowledge to meet a recognized need; or (C) a systematic application of knowledge toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements.

"(f)(1) Each Federal agency which has total appropriations in excess of $100,000,000 for reseach or research and development for fiscal year 1983 or any fiscal year thereafter shall establish a SBIR program.

"(2) Each Federal agency which is required to establish a SBIR program under paragraph (1) shall, to the extent required in Acts authorizing appropriations for each such agency, reserve for expenditure with small business concerns in connection with such SBIR program—

"(A) not less than 0.2 per centum of its total appropriations for research or research and development in the first fiscal year in which it is required to establish a SBIR program, "(B) not less than 0.6 per centum of such total appropriations in the second such fiscal year, and

"(C) not less than 1 per centum of such total appropriations in all subsequent such fiscal years.

"(g) For the purpose of meeting the requirements of subsection (f), no Federal agency shall make available, from that portion of its total appropriations for research or research and development which is available for obligation for basic research, an amount which exceeds 0.2 per centum of such portion in the first fiscal year in which it is required to establish a SBIR program, 0.6 per centum of such portion in the second such fiscal year, or 1 per centum of such portion in subsequent such fiscal years.

"(h) Each Federal agency required by subsection (f) to establish a small business innovation research program shall—

"(1) unilaterally determine categories of projects to be in its SBIR program;

"(2) issue small business innovation research solicitations in accordance with a schedule determined cooperatively with the Small Business Administration;

"(3) unilaterally receive and evaluate proposals resulting from SBIR solicitations;

"(4) unilaterally select awardees for its SBIR funding agreements;

"(5) administer its own SBIR funding agreements (or delegate such administration to another agency);

"(6) make payments to recipients of SBIR funding agreements on the basis of progress toward or completion of the funding agreement requirements; and

"(7) make an annual report on the SBIR program to the Small Business Administration and the Office of Science and Technology Policy.

"(i) In addition to the requirements of subsection (f), each Federal agency which has total appropriations in excess of $20,000,000 for research or research and development for fiscal year 1983 or any fiscal year thereafter shall establish goals specifically for funding agreements for research or research and development to small business concerns.

"(j) Each Federal agency required by this section to have a SBIR program or to establish goals shall report annually to the Small Business Administration the number of awards pursuant to funding agreements over $10,000 in amount and the dollar value of all such awards, identifying SBIR awards and comparing the number and amount of such awards with awards to other than small business concerns.

"(k) In addition to the requirements of subsection (h), each Federal agency shall encourage and facilitate the general conduct of its SBIR program to provide maximum opportunity for small businesses to engage in specified agency research and development objectives through the establishment of procedures which provide for—

"(1) simplified, standardized, and timely SBIR solicitations; and

"(2) a simplified, standardized funding process which provides for (A) the timely receipt and review of proposals; (B) outside peer review, as appropriate; (C) protection of proprietary information provided in proposals; (D) selection of awardees; (E) retention of rights in data generated in the performance of the contract by the small business concern; (F) transfer of title to property provided by the agency to the small business concern if such a transfer would be more cost effective than recovery of the property by the agency; (G) cost sharing; and (H) cost principles and payment schedules.

"(1) The Director of the Office of Science and Technology Policy, in consultation with the Federal Coordinating Council for Science, Engineering and Technology, shall—

"(1) independently survey and monitor all phases of the implementation and operation of SBIR programs within agencies required to establish a SBIR program, including compliance with the expenditures of funds according to the requirements of subsection (f) of this section; and

"(2) report not less than annually, and at such other times as the Director may deem appropriate, to the Senate and the House of Representatives on all phases of the implementation and operation of SBIR programs within agencies required to establish a SBIR program, together with such recommendations as the Director may deem appropriate.".

SEC. 5. The Comptroller General shall, not later than 5 years following the enactment of this Act, report to the Senate and the House of Representatives on the quality, quantity, and nature of research conducted under the amendments made by this Act, and the effect the amendments made by this Act have had on the agencies' research and development programs, together with such recommendations as the Comptroller General may deem appropriate.

Union Calendar No. 279

97TH CONGRESS
2D SESSION

H. R. 4326

[Report No. 97–349, Parts I, II, III, IV, V, VI, and VII]

A BILL

To amend the Small Business Act to strengthen the role of the small, innovative firms in federally funded research and development, and to utilize Federal research and development as a base for technological innovation to meet agency needs and to contribute to the growth and strength of the Nation's economy.

NOVEMBER 20, 1981

Reported from the Committee on Small Business, with an amendment, and referred with instructions

MARCH 10, 1982

Reported from the Committee on Energy and Commerce, with an amendment

MARCH 16, 1982

Reported from the Committee on Veterans' Affairs, with an amendment

MARCH 16, 1982

Reported from the Committee on Science and Technology, with an amendment

MARCH 16, 1982

Reported from the Committee on Foreign Affairs

MARCH 16, 1982

Reported from the Committee on Armed Services, with amendments

MARCH 16, 1982

Reported from the Permanent Select Committee on Intelligence, with an amendment

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97TH CONGRESS
2D SESSION

H. R. 6587

To amend the Small Business Act to strengthen the role of the small, innovative firms in federally funded research and development, and to utilize Federal research and development as a base for technological innovation to meet agency needs and to contribute to the growth and strength of the Nation's economy.

IN THE HOUSE OF REPRESENTATIVES

JUNE 14, 1982

Mr. MITCHELL of Maryland introduced the following bill; which was referred to the Committee on Small Business

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A BILL

To amend the Small Business Act to strengthen the role of the small, innovative firms in federally funded research and development, and to utilize Federal research and development as a base for technological innovation to meet agency needs and to contribute to the growth and strength of the Nation's economy.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. This Act may be cited as the "Small Business Innovation Development Act of 1982".

SEC. 2. (a) The Congress finds that—

(1) technological innovation creates jobs, increases productivity, competition, and economic growth, and is a valuable counterforce to inflation and the United States balance-of-payments deficit;

(2) while small business is the principal source of significant innovations in the Nation, the vast majority of federally funded research and development is conducted by large businesses, universities, and Government laboratories; and

(3) small businesses are among the most cost-effective performers of research and development and are particularly capable of developing research and development results into new products.

(b) Therefore, the purposes of this Act are—

(1) to stimulate technological innovation;

(2) to use small business to meet Federal research and development needs; and

(3) to increase private sector commercialization innovations derived from Federal research and development.

SEC. 3. Section 9(b) of the Small Business Act is amended—

(1) by striking out "and" at the end of paragraph (2);

(2) by striking out the period at the end of paragraph (3) and inserting in lieu thereof "; and"; and

(3) by adding at the end thereof the following:

"(4) to develop and maintain a source file and an information program to assure each qualified and interested small business concern the opportunity to participate in Federal agency small business innovation research programs;

"(5) to coordinate with participating agencies a schedule for release of SBIR solicitations, and to prepare a master release schedule so as to maximize small businesses' opportunities to respond to solicitations;

"(6) to independently survey and monitor the operation of SBIR programs within participating Federal agencies; and

"(7) to report not less than annually to the Committee on Small Business of the Senate and the Committee on Small Business of the House of Representatives on the SBIR programs of the Federal agencies and the Administration's information and monitoring efforts related to the SBIR programs.".

SEC. 4. Section 9 of the Small Business Act is amended by adding at the end thereof the following new subsections:

"(e) For the purpose of this section—

"(1) the term 'extramural budget' means the sum of the total obligations minus amounts obligated for such activities by employees of the agency in or through Government-owned, Government-operated facilities, except that for the Agency for International Development it shall not include amounts obligated solely for general institutional support of international research centers or for grants to foreign countries.

"(2) the term 'Federal agency' means an executive agency as defined in section 105 of title 5, United States Code, or a military department as defined in section 102 of such title, except that it does not include the Central Intelligence Agency, the National Security Agency or the Defense Intelligence Agency.

"(3) the term 'funding agreement' means any contract, grant, or cooperative agreement entered into between any Federal agency and any small business for the performance of experimental, developmental, or research work funded in whole or in part by the Federal Government;

"(4) the term 'Small Business Innovation Research Program' or 'SBIR' means a program under which a portion of a Federal agency's research or research and development effort is reserved for award to small business concerns through a uniform process having—

"(A) a first phase for determining, insofar as possible, the scientific and technical merit and feasibility of ideas submitted pursuant to SBIR program solicitations;

"(B) a second phase to further develop the proposed ideas to meet the particular program needs, the awarding of which shall take into consideration the scientific and technical merit and feasibility evidenced by the first phase and, where two or more proposals are evaluated as being of approximately equal scientific and technical merit and feasibility, special consideration shall be given to those proposals that have demonstrated third phase, non-Federal capital commitments; and

"(C) where appropriate, a third phase in which non-Federal capital pursues commercial applications of the research or research and development and which may also involve follow-on non-SBIR funded production contracts with a Federal agency for products or processes intended for use by the United States Government; and

"(5) the term 'research' or 'research and development' means any activity which is (A) a systematic, intensive study directed toward greater knowledge or understanding of the subject studied; (B) a systematic study directed specifically toward applying new knowledge to meet a recognized need; or (C) a systematic application of knowledge toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements.

"(f) Each Federal agency which has an extramural budget for research or research and development in excess of $100,000,000 for fiscal year 1982, or any fiscal year thereafter, shall expend not less than 0.2 per centum of its extramural budget in fiscal year 1983 or in such subsequent fiscal year as the agency has such budget, not less than 0.6 per centum of such budget in the second fiscal year thereafter, not less than 1 per centum of such budget in the third fiscal year thereafter, and not less than 1.25 per centum of such budget in all subsequent fiscal years with small business concerns specifically in connection with a small business innovation research program which meets the requirements of the Small Business Innovation Development Act of 1982 and regulations issued thereunder: *Provided*, That any Federal agency which has an extramural budget for research or research and development in excess of $10,000,000,000 for fiscal year 1982 shall expend not less than 0.1 per centum of its extramural budget in fiscal year 1983, not less than 0.3 per centum of such budget in the second fiscal year thereafter, not less than 0.5 per centum of such budget in the third fiscal year thereafter, not less than 1 per centum of such budget in the fourth fiscal year thereafter, and not less than 1.25 per centum of such budget in all subsequent fiscal years with small business concerns specifically in connection with a small business innovation research program which meets the requirements of the Small Business Innovation Development Act of 1982 and regulations issued thereunder: *Provided further*, That a Federal agency shall not make available for the purpose of meeting the requirements of this subsection an amount of its extramural budget for basic research or research and development which exceeds the percentage specified herein. Funding agreements with small business concerns for research or research and development which result from competitive or single source selections other than under a small business innovation research program shall not be counted as meeting any portion of the percentage requirements of this subsection.

"(g) Each Federal agency required by subsection (f) to establish a small business innovation research program shall, in accordance with this Act and regulations issued hereunder—

"(1) unilaterally determine categories of projects to be in its SBIR program;

"(2) issue small business innovation research solicitations in accordance with a schedule determined cooperatively with the Small Business Administration;

"(3) unilaterally receive and evaluate proposals resulting from SBIR proposals;

"(4) unilaterally select awardees for its SBIR funding agreements;

"(5) administer its own SBIR funding agreements (or delegate such administration to another agency);

"(6) make payments to recipients of SBIR funding agreements on the basis of progress toward or completion of the funding agreement requirements; and

"(7) make an annual report on the SBIR program to the Small Business Administration and the Office of Science and Technology Policy.

"(h) In addition to the requirements of subsection (f), each Federal agency which has a budget for research or research and development in excess of $20,000,000 for any fiscal year beginning with fiscal year 1983 or subsequent fiscal year shall establish goals specifically for funding agreements for research or research and development to small business concerns, and no goal established under this subsection shall be less than the percentage of the agency's research or research and development budget expended under funding agreements with small business concerns in the immediately preceding fiscal year.

"(i) Each Federal agency required by this section to have an SBIR program or to establish goals shall report annually to the Small Business Administration the number of awards pursuant to grants, contracts, or cooperative agreements over $10,000 in amount and the dollar value of all such awards, identifying SBIR awards and comparing the number and amount of such awards with awards to other than small business concerns.

"(j) The Small Business Administration, after consultation with the Administrator of the Office of Federal Procurement Policy, the Director of the Office of Science and Technology Policy, and the Intergovernmental Affairs Division of the Office of Management and Budget, shall, within one hundred and twenty days of the enactment of the Small Business Innovation Development Act of 1981, issue policy directives for the general conduct of the SBIR programs within the Federal Government, including providing for—

"(1) simplified, standardized, and timely SBIR solicitations;

"(2) a simplified, standardized funding process which provides for (A) the timely receipt and review of proposals; (B) outside peer review for at least phase two proposals, if appropriate; (C) protection of proprietary information provided in proposals; (D) selection of awardees; (E) retention of rights in data generated in the performance of the contract by the small business concern; (F) transfer of title to property provided by the agency to the small business concern if such a transfer would be more cost effective than recovery of the property by the agency; (G) cost sharing; and (H) cost principles and payment schedules;

"(3) exemptions from the regulations under paragraph (2) if national security or intelligence functions clearly would be jeopardized;

"(4) minimizing regulatory burden associated with participation in the SBIR program for the small business concern which will stimulate the cost-effective conduct of Federal research and development and the likelihood of commercialization of the results of research and development conducted under the SBIR program; and

"(5) simplified, standardized, and timely annual report on the SBIR program to the Small Business Administration and the Office of Science and Technology Policy.

"(k) The Director of the Office of Science and Technology Policy, in consultation with the Federal Coordinating

Council for Science, Engineering and Research, shall, in addition to such other responsibilities imposed upon him by the Small Business Innovation Development Act of 1982—

"(1) independently survey and monitor all phases of the implementation and operation of SBIR programs within agencies required to establish an SBIR program, including compliance with the expenditures of funds according to the requirements of subsection (f) of this section; and

"(2) report not less than annually, and at such other times as the Director may deem appropriate, to the Committees on Small Business of the Senate and the House of Representatives on all phases of the implementation and operation of SBIR programs within agencies required to establish an SBIR program, together with such recommendations as the Director may deem appropriate.".

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